POSSIBILITIES AND EFFICIENCY ANALYSIS OF USING ARDUINO MICROCONTROLLER IN IOT PROJECTS

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Annotation: *This article highlights the possibilities of using Arduino micro-controllers in IoT projects and their effectiveness analysis. The technical characteristics, architecture and application areas of Arduino Uno, Leonardo, Nano, Mega, Mini, Micro and LilyPad boards have been compared. Given the advantages and limitations of each microcontroller, the application in real-time monitoring, automation and data processing processes in IoT systems is annotated. The programming capabilities, energy efficiency and importance of Arduino boards in educational and practical projects are also discussed.*

Keywords: *Arduino Uno, Arduino Mega, Arduino Nano, microcontroller, IoT, real-time monitoring, automation, PWM, sensors, energy efficiency, Arduino IDE, programming*

Arduino Uno is a device based on the ATmega328 microcontroller. It includes everything necessary for convenient operation with a microcontroller: 14 digital inputs/outputs (6 of which can be used as PWM outputs), 6 analog inputs, a crystal resonator with a frequency of 16 MHz, a USB connector, a power connector, an internal programming connector (ICSP) and a reset button.rduino Uno is a device based on the ATmega328 microcontroller.

Fig.1. Arduino UN microcontroller

The Arduino Leonardo is a device based on the ATmega32U4 microcontroller. It includes everything you need to work with this microcontroller: 20 digital inputs / outputs (of which 7 can act as PWM outputs, 12 can act as analog inputs), 16 MHz crystal resonator, micro USB connector, power connector, ICSP (in-Circuit sequential programming) connector, and reset button.he Arduino Leonardo is a device based on

the ATmega32U4 microcontroller. It includes everything you need to work with th [1-3].

Fig.2. Arduino Leonardo microcontroller

Leonardo differs from all previous boards in that its USB controller is installed directly on the ATmega32U4 microcontroller, which eliminates the need for an additional processor.

Fig.3. Arduino Nano microcontroller

For this reason, when connected to a computer, Leonardo can be defined not only as a virtual (CDC) COM port, but also as a simple mouse or keyboard eonardo differs from all previous boards in that its USB controller is installed directly on the. Arduino Nano is a functional analog version of Arduino Uno. It has a slightly smaller function compared to the Arduino Uno, but its size is also compact.

The main differences between the Arduino Nano board and the Arduino Uno are the lack of a DC connector, the use of a Mini USB port instead of USB B, and the use of a different chip for the USB-TTL – Arduino Nano converter. It was based on the FT232 instead of the ATMega16U2 in Arduino Uno [4]. The Arduino Nano plate, like the Arduino Uno, is very popular among enthusiasts due to its small size and relatively low price. Arduino Mega 2560 is a device based on the ATmega2560

microcontroller.rduino Mega 2560 is a device based on the ATmega2560 microcontroller.

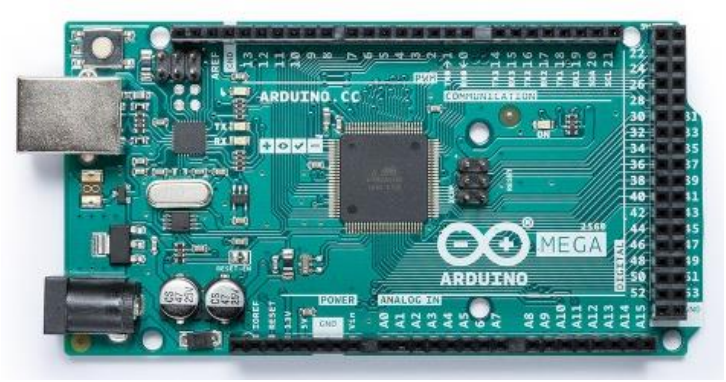

Fig.4. Arduino Mega microcontroller

It includes everything you need to work comfortably with a microcontroller: 54 digital inputs / outputs (15 of which can be used as PWM outputs), 16 analog inputs, 4 UART (hardware transmitters to implement serial interfaces), 16 MHz crystal resonator, USB connector, power connector, ICSP connector for circuit programming and reset button. To start working with the device, it is possible to simply connect to the computer via an AC/DC adapter or a power supply from a battery or a USB cable. The Mega 2560 is an updated version of the Arduino Mega.

The Arduino Mega 2560 differs from all previous boards in that it uses the ATmega16U2 microcontroller instead of the FTDI chip to convert USB-UART interfaces (ATmega8U2 in the R1 and R2 versions of the board). The Mega 2560 version adds resistance on the R2 board to pull the HWB line of the 8u2 microcontroller to the ground.he Arduino Mega 2560 differs from all previous boards in that it uses the ATmega16U2 microcontroller instead o.

The changes to the R3 board are listed below:

• Pinout added SDA and SCL pins (next to the AREF pin), as well as two new pins located next to the RESET pin. Allows 1 - IOREF-expansion boards to be adjusted to the Arduino operating voltage.

• Improved noise immunity of the recovery period.

• ATmega16U2 microcontroller replaced with 8u2.

The Arduino Mini is a small microprocessor-based device designed for use with panels or applications that require high space. Initially, the device was based on the ATmega168 microcontroller, which has now been replaced by the ATmega328 microcontroller. The device includes: 14 digital inputs / outputs (6 of which can be used as PWM outputs), 8 analog inputs, and a 16 MHz crystal [5]. The Arduino Mini can be powered using a dedicated USB-serial adapter or any other USB-serial or RS232-serial interface converter with TTL voltage levels.

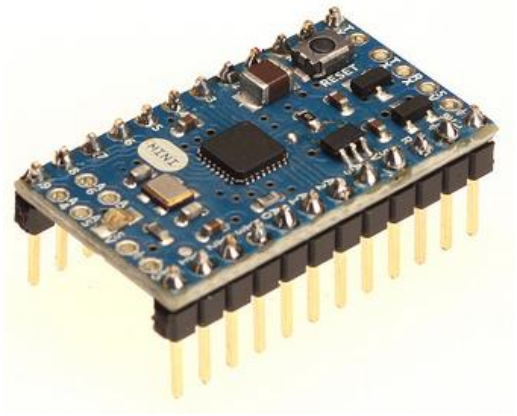

Fig.5. Arduino Mini microcontroller

The new version of the Arduino Mini (R5) has updated the PCB for the ATmega328 microcontroller, so all components are now located on the front of the board. In addition, a reset button was added. At the same time, in the new version of the Arduino Mini, pinout is completely similar to the previous version of the R4.

The Arduino Micro is an Arduino Leonardo built on a compact board. The difference is that it does not have its own socket for external power, but it can be connected directly to the VI pin.

Fig.6. Arduino microcontrollers

In other cases, the connection and interaction methods are identical to those of Arduino Leonardo. It also has a USB flash and a single ATmega32u4 microcontroller for program execution; it can also act as a keyboard or mouse; it also provides the same amount of memory, digital, analog and PWM ports.

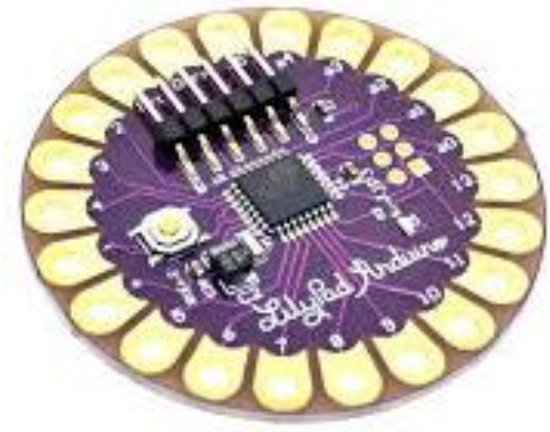

Fig.7. Arduino LilyPad microcontroller

The Arduino LilyPad is a very interesting device.n other cases, the connection and interactionmethods are identical to those of Arduino Leonardo. Secondly, it does not support mechanical connections with boards. It is designed for small independent devices. The round shape allows the connectors to be evenly distributed in a circle, and its small size (2 inches in diameter) makes it ideal for portable portable devices.

This device is easy to hide, and also several manufacturers have developed special devices for Lilypad: screens, light sensors, even boxes of power batteries that can be sewn into the fabric. Some technologies have been abandoned to make LilyPad as small as possible and as light as possible. LilyPad does not have a voltage regulator on board, so it should not exceed at least 2.7 volts and 5.5 volts to power it.

Comparison table of Arduino microcontrollers

Arduino device type	Microcontroller	Workforce [V]	Digital input/output	PVM channels	Analog input/output	Maximum current on I/O pins [mA]	Flash memory (KB)	Fast memory (KB)	EEPROM-memory (KB)	Clock frequency (MHz)	Dimensions (mm)	USB connection
Uno	ATmega328p	5	14	6	6	40	32	2	1	16	69x53	USBA-B
Leonardo	ATmega32U4	5	20	7	12	40	32	2,5	1	16	75x54	micro-USB
Nano	ATmega328p	5	14	6	8	40	32	2	1	16	18x45	mini-USB
Mega	ATmega2560	5	54	14	16	40	256	8	4	16	102x53	USBA-B
Mini	ATmega328	5	14	6	6	40	32	2	1	16	30x18	USB-Serial
Micro	ATmega32u4	5	20	7	12	40	32	2,5	1	16	48x18	micro-USB
LilyPad	ATmega328p	2,7 5,5	20	6	6	40	32	2	1	8	Ø50	USB-Serial

Arduino UNO memory consists of three different types: program stored flash memory, 32 KB maximum, 2 KB memory, for storing and rewriting the parameters used in the program, and 1 kilogram of permanent memory, standing when restarting the controller.rduino UNO memory consists of three different types: program stored flash memory, 32 KB maximum, 2 KB memory, for storing and rewriting the parameters used in the program, and 1 kilogram of permanent memory, standing when restarting the [5].

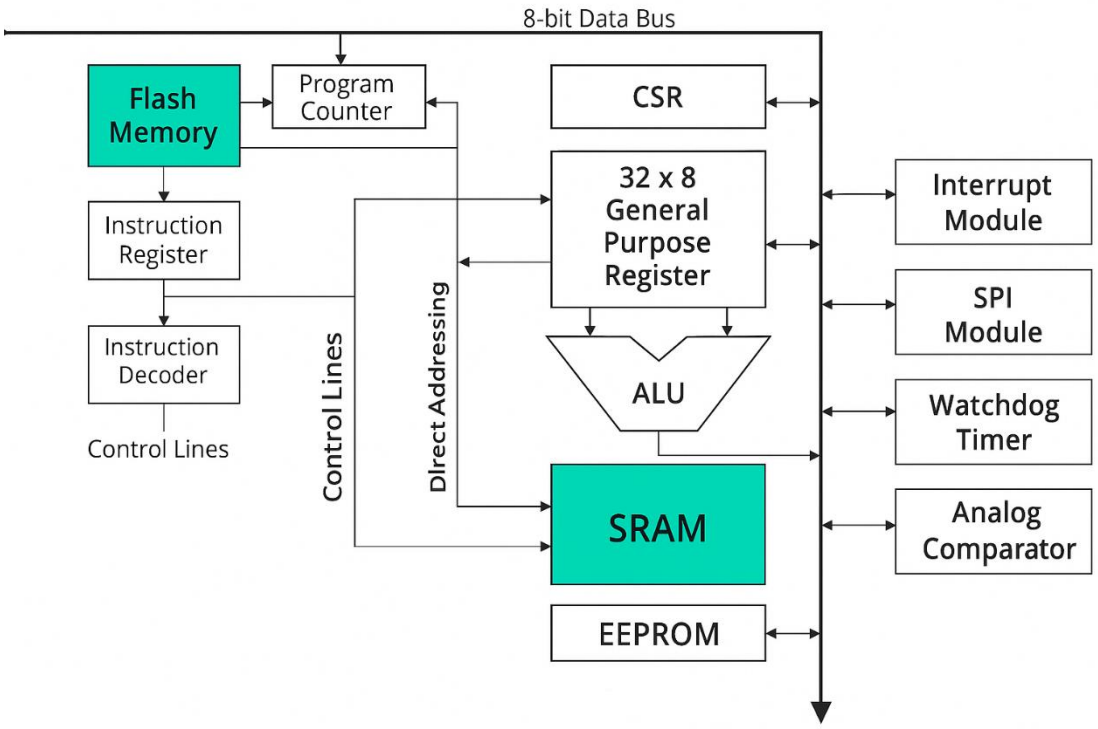

Fig.8. Arduino internal architecture

The Atmega328 processor is connected to 14 digital and 6 analog ports, 5V voltage pins to the USB connector, GND.

Digital input / output ports are above and numbered from 0 to 13. A digital output is an electrical connection with two logics: 0 and 1 or TRUE and FALSE, or Arduino, which works like a high and LOW syntax.

Digital inputs / outputs marked " ~ " provide PWM (pulse width modulation). PWM pins have the ability to distribute voltage by varying the signal between 0 v and 5 v. The 5 V voltage of PWM pins can provide only a fraction of the period, not always. The Arduino PWM frequency was about 490.igital inputs / outputs marked " ~ " provide PWM (pulse width modulation). PWM pins have the ability to distribute voltage by varying the signal between 0 v and 5 v. The 5 V voltage of PWM pins can provide only a fraction of the period, not always. The Arduino PWM frequency was about 490 [6-7]. That is, the approximate period of the signal from 5 V to 0 V is placed in one second.

More voltage is simulated if the 5V transmission of a large part of the time continues. For example, if a 5 V signal lasts half an hour, a 2.5 V voltage is simulated.

Arduino microcontrollers are widely used in IoT and automation projects with simple structure, low cost and wide capabilities. Different Arduino boards (Uno, Mega,

Nano, etc.) are selected based on the complexity and requirements imposed by the projects.

Due to their ease of programming, flexibility to modules and expansion capabilities, they can be used effectively not only in scientific and practical research, but also in the educational process.

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