Use Arduino and the Mblock as the Process Control of Innovation Study Tool: Case Study of freshmen of University

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ABSTRACT

A novel teaching method of sequence control of the automation is proposed in this paper. The Arduino is used to replace the PLC used in the traditional industrial automation. The software of the mBlock is coded by the block instructure. The block-diagram-liked view can easily cuase the freshmen of the university to accept the conception of sequence logic of the automation. Finally, the experimental result will shows the detailed conception proposed in this paper.

KEYWORDS: *mechatronics; Arduino; mBlock*

I. INRODUCTION

Process Control is the most important part in the industrial automation. The machines will process automatically by the setup procedures according to the signals from the sensors. Usually, the control unit is implemented by the distributed control system (DCS) or the programmable logical controller (PLC). To code the procedure, the higher linguistic program language is used in the DCS, such as ANSI C. To implement the process control in the PLC usually is to design the ladder diagram. If there is the clearly logic concept, the ladder diagram is easier to learn. However, for most freshman, they are the first time to contact the program design of the computer. It is very different from the oral description. At the same time, the digital logic is firstly introduced to these freshmen. To accept these two kind knowledgement tests the learning ability of the freshman of university.

Recently, the maker fairs introduce the Arduino for the use of the process unit [1]. It belongs to the open source. Therefore, it is widely applied many creative fields in the short time. At the same time, the process capability of the Arduino is increased more and more. Therefore, the Arduino appliance also becomes the plenary program in the university. However, the programming of the Arduino uses the C-liked programming software. It is also difficult for the freshman to build the skill of programming. Someone modifies the Scratch software designed by the MIT to the software of mBlock [2]. The programming method is written by the blocks. By piling

the blocks, the structure of the blocks can be finished the logical programming. Therefore, the Arduino with the mBlock becomes a very simple tool learning the programming for the new programmer.

In this paper, the novel teaching method is to use the Arduino with the mBlock to learn and implement the Process Control. The novel teaching method is also applied to implement the training of the skill evaluation of the Mechatronics. By piling the blocks, the sequence control of the mechatronics platform will work properly to fit the requirement of the skill evaluation. The novel teaching method will introduction the Process Control concept to the freshman in the university.

II. Mechatronics Platform of Skill Evaluation

There is a governmental department called the Skill Evaluation Center designed to evaluate the different skill for careers. One skill evaluation called the Mechatronics is focused on the process control of the automation. There are two levels : level II and level III in the system. The examination is divided into two parts: science and technique. There are five subjects in the technical examination in level III. The candidates have to choice subject and finished all requirements of the hardware and the software.

The first subject is called "Shape Detection and Transmission". The platform is designed in the fig. 1.
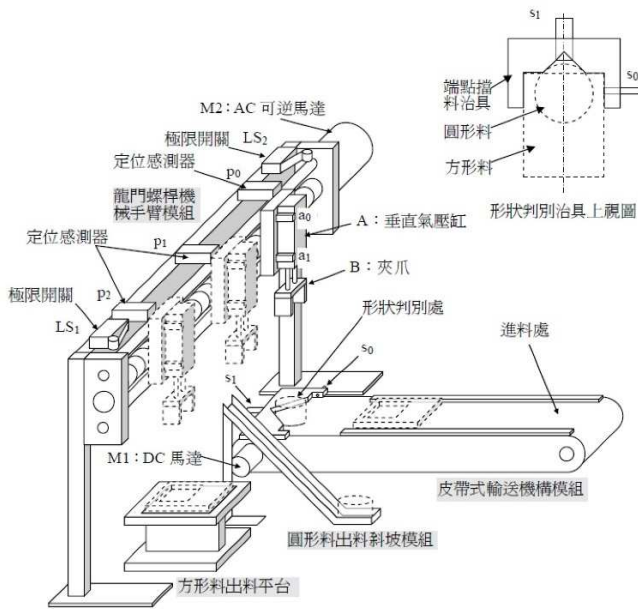
Figure 1. Platform of "Shape Detection and Transmition" [3]

The required function is to put the block (circle or square) in the input entrance. The conveyor will move the block to the shape detecting unit. Then, the robot arm will lower down. After grabbing the block, the robot arm will raise up. If the shape is circle, the robot arm will move to point p1 and release the block. If the shape is square, the robot arm will move to point p2 and lower down to put the block onto the platform.

The second subject is called "Color Detection and Attitude Modification." The platform is designed as fig. 2.
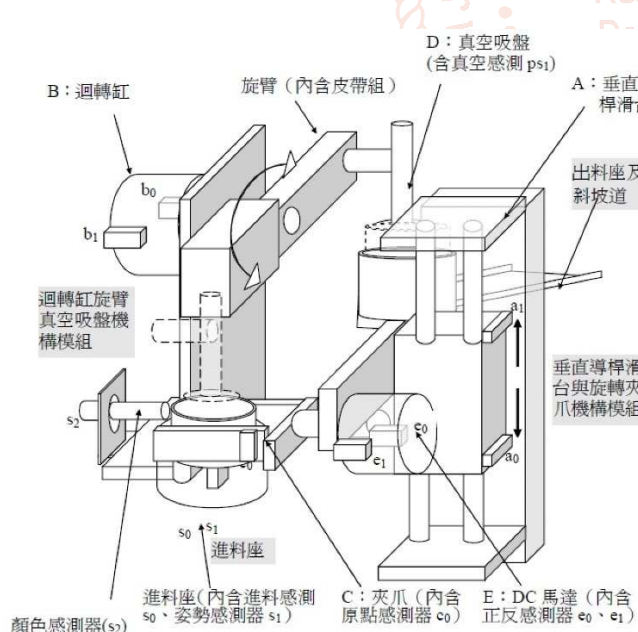

Figure 2. Platform of "Color Detection and Attitude Modification" [3]

The required function is to put the block in the entrance side. If the color is black, then the yellow light is on and waiting for manual moving. If the color is red and the open side is up, then the vacuum sucker sucks the block to the exit side. If the color is red and the open side is down, then the air-pressured claw grabs the block to move the open side up. Then, the vacuum sucker sucks the block to the exit side.

The third subject is called "Attitude Detection and Change". The platform is designed in fig. 3.
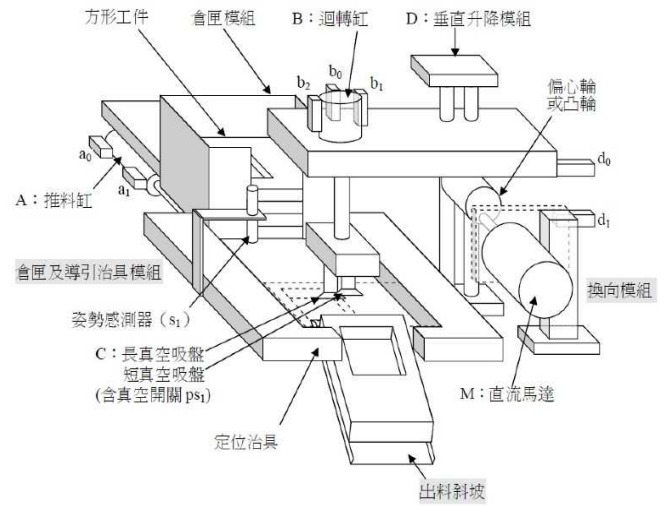

Figure 3. Platform of "Attitude Detection and Chane" [3]

The required function is to put the block in the entrance side. If the fillister is in the right hand side, then the yellow light is on and waiting for manual moving. If the fillister is in the left hand side, then the gyration vat rotates to the block side with moving in the vertical up and down in order to change the block to the exit side.

The fourth subject is called "Material Division and Process". The platform is designed in fig. 4.
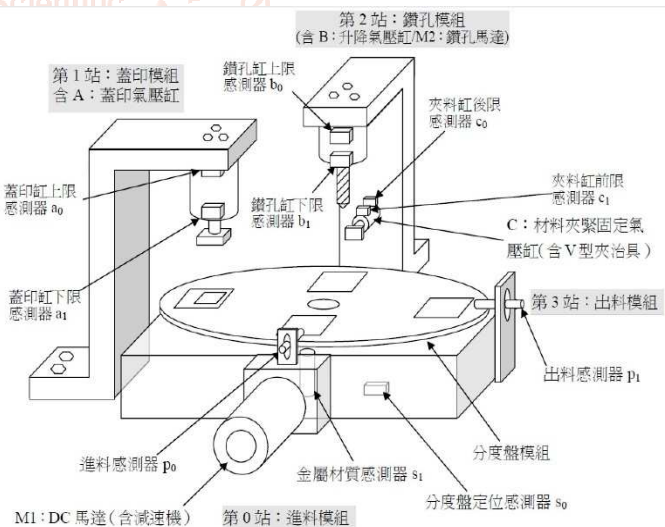

Figure 4. Platform of "Material Division and Process" [3]

The required function is to put the block in the entrance side. The sensor will detect whether is metalloporphyrin. If the block is metal material, then the rotation plate will rotate the block to the station 1. The stamping motion will press by the air pressure. Then the rotation plate will rotate the block to the exit side. If the block is plastic material, then the rotation plate will rotate the block to station 2. The drilling motion will process by the electrical motor. Then the rotation plate will rotate the block to the exit side.

The fifth subject is called "Weight Distinguish and Arrangement". The platform is designed in fig. 5.
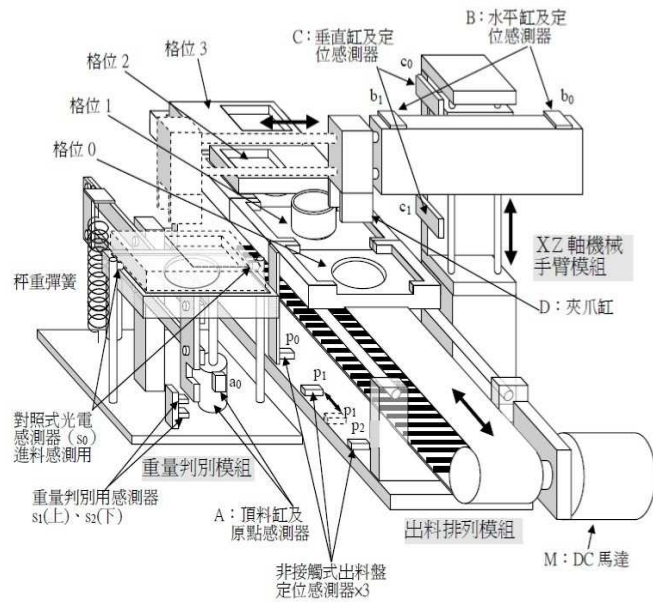
Figure 5. Platform of "Weight Distinguish and Arrangement" [3]

The required function is to put the block in the entrance side. The weight sensor will detect the block' weight. If the block is the heavy material, then the X-Z table robot arm will grab the block. The block will be moved to the lattice 1 along with the conveyor. If the block is the light material, then the movement is similar with the heavy one except the lattice 3.

III. Arduino and mBlock
A. Arduino
Arduino is belonged to the Open Source hardware. There are many pins for digital usages. The digital pin will be defined as input/output in the program. Therefore, the hardware arrangement is easily for industrial control while comparing to the PLC. There are some built-in analog input pins. They can easily access the input signals of the sensors. Although there is no analog output pin, but the Arduino offers the PWM output function. Therefore, the Arduino can offer the whole demand for industrial control.

There are different types Arduino for the choice of the different applications. The functions of the different Arduino boards are listed in the table III. In this paper, the type MEGA 2560 is chosen to be the main control board. The board view is shown in fig. 6.
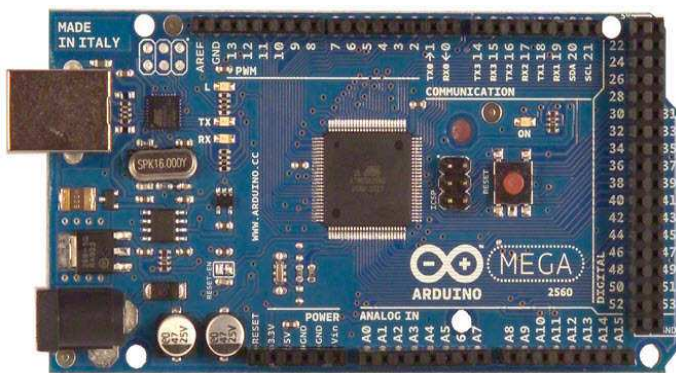

Figure 6. Platform of "Weight Distinguish and Arrangement" [2]

The spec of the Arduino board of MEGA 2560 is listed in tableI.

TABLE I. SPEC OF MEGA 2560 [2]

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
Length	101.52 mm
Width	53.3 mm
Weight	37 g

B. mBlock
The mBlock software is modified from the Scratch software. It is programmed by the graphical block, shown in fig. 7.
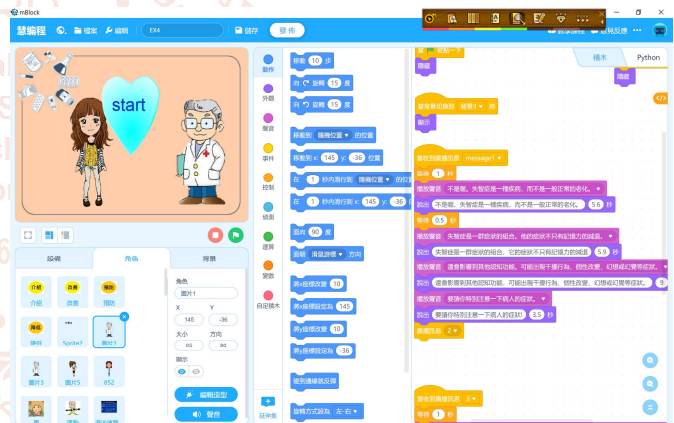

Figure 7. Screen Snap of mBlock

The shape of the command block is similar to the flow chart usually used in the program education. Hence, according the flow chart of the design thinking, user can easily converts the chart to the command block to finfish the programming.

IV. Experimental Results
A. Hardware Design
The voltage used in industrial actuators and the sensors is 24 Volts. The voltage level of the micro process is 5 Volts. Hence, some voltage-matched circuits are necessary for this application.

The relay is used to convert the 5V to 24V output. By the normal open mode of the relay, if the input is excited (5V), then the output will be short node. The external voltage (24V) can be used to applied to the industrial actuators. Due to the high frequency switching, the solid state relay will be used in this paper. The board of DB-24RD is used to achieved the requirement, designed by the ICP DAS CO. The top view of the DB-24RD is shown in fig. 8.
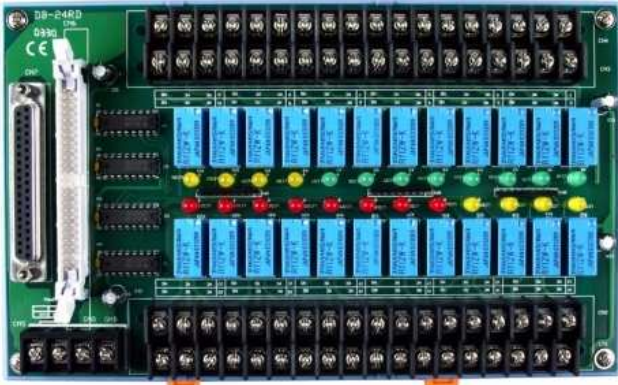
Figure 8. Top View of the DB-24RD [4]

The photo coupler is used to convert the 24V input to 5V signal. By the photo coupler, the current can be isolated between the different voltages. It is a very good safe method to protect the circuit. The board of DB-24PD is used to achieved the requirement, designed by the ICP DAS CO. The top view of the DB-24PD is shown in fig. 9.

Figure 9. Top View of the DB-24PD [5]

B. Mechatronics Platform

The traditional controller for the skill evaluation is the PLC. Therefore, the related document is defined by the PLC node. In this paper, we substitute the Arduino for the PLC. The related list is shown in table II.

TABLE II.   RELATION OF THE PLC NODE AND ARDUINO PIN

Input		
Function	**PLC node**	**Arduino pin**
Stamp cylinder upper limiter	X0	40
Stamp cylinder lower limiter	X1	41
Drilling cylinder upper limiter	X2	42
Drilling cylinder lower limiter	X3	43
Clip cyliner front limiter	X4	44
Clip cylinder back limiter	X5	45
Dividing plate climp sensor	X6	46
Material sensor	X7	47
Input sensor	X10	48
Output sensor	X11	49
Output		
Function	PLC node	Arduino pin
Stamp cylinder down	Y0	30
Drilling cylinder down	Y2	32
Drilling cylinder up	Y3	33
Clip cylinder stretch	Y4	34
Clip cylinder shrink	Y5	35
Dividing plate motor on	Y6	36
Drilling motor on	Y7	37

C. mBlock Code

In this paper, we take the fourth subject for example. In this example, the action can be divided into the main loop and three sub-function programs. The three sub-function programs are: the drilling motion, the stamping motion and the dividing plate rotating motion.

The dividing plate is divided into four parts. The four stations are located in four quadrant. While rotating one quadrant, the sensor will give one pulse. Therefore, the dividing plate rotating function is design to control the plate rotated one quadrant each time. Firstly, make the dividing plate motor on. After the plate leaving the sensor, wait for the plate covering on the sensor. Then, turn off the dividing plate motor. The block code is shown in fig. 10.
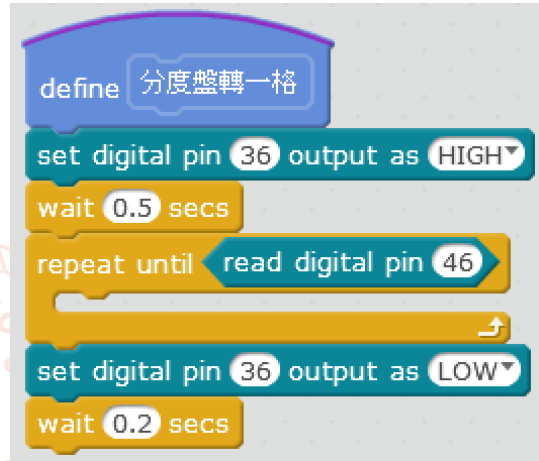

Figure 10. Sub-function of Dividing Plate Rotating Motion

The sub-function of stamping motion is designed to make the stamping cylinder down and up to finish the stamp motion. Turn on stamping cylinder switch. The air pressure will force the cylinder to low down. When the stamp cylinder lower limiter is on, we wait 2 seconds to finish the stamping motion. Then turn off the stamping cylinder switch. The cylinder will raise up and touch the stamp cylinder upper limiter. The block code is shown in fig. 11.
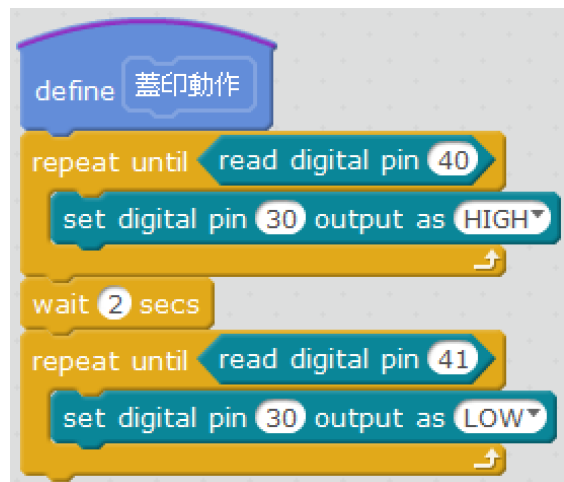

Figure 11.   Sub-function of Stamping motion

The sub-function of drilling motion is designed to clip the block and drill for 2 seconds. The motion is designed by the sequence motion: clip stretching, drill lowering down, drilling, drill raising up, clip shrinking. The detailed block code is shown in fig. 12.

Figure 12. Sub-function of Drilling motion

The main loop is designed to detect the material and follow up the different chosen motion. If the block is metal material, then the sensor (pin 48) will be on. The block will be rotated to station 1 and stamped. The block will be rotated to station II and drilled, in the other case. The detailed block code is shown in fig. 13.

Figure 13. Main Loop of the Fourth Subject

D. Experimental Results

The wiring conditions are shown in fig. 14 ~fig. 15. The fig. 14 shows the wiring between the Arduino and the terminal boards. The wiring condition of the boards of DB-24PD and DB-24RD is shown in fig. 15.

Figure 14. Wiring between the Arduino and the Terminal Board
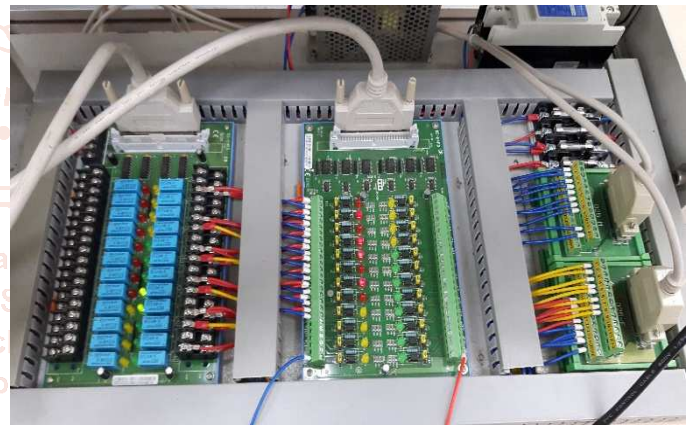

Figure 15. wiring condition of the boards of DB-24PD and DB-24ZRD

The experimental mechatronics platform of the fourth subject is shown in fig. 16.
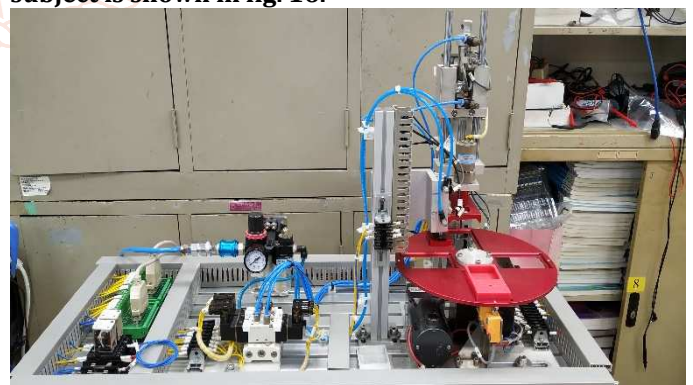
**Figure 16. Experimental mechatronics platform
Please refer the experimental video in the YouTube.
(https://youtu.be/LiWu6rzuoYM)**

Conclusion

Traditionally the automation is implemented by the PLC. The ladder program suffer the freshmen of the university. In this paper, the novel teaching of automation is to use the Arduino and the mBlock software to replace the PLC. The easily understood block diagram make the student accept the conception of sequence control of automation. The experimental results also shows the great advantage, too.

References

[1] http://www.arduino.cc

[2] http://www.mblock.cc

[3] http://sites.ccvs.kh.edu.tw/board.php?courseID=120&f=doc&cid=20942

[4] https://icpdas.ro/en/accesorii-pentru-placi-de-calculator/1324-db-24rd-12-din-cr.html

[5] https://icpdas.ro/en/accesorii-pentru-placi-de-calculator/1337-db-24pd-din-cr.html

TABLE III.   COMPARING LIST OF DIFFERENT ARDUINO BOARDS 1

Name	CPU	Voltage	Frequency	Analog in/out	Digital all/pwm	EEPROM	SRAM	Flash	USB
Uno	ATmega328P	5 V / 7-12 V	16 MHz	6/0	14/6	1	2	32	○
Pro Mini	ATmega328P	3.3 V / 3.35-12V 5 V / 5-12 V	8 MHz 16 MHz	6(8)/0	14/6	1	1	32	×
Pro	ATmega168 ATmega328P	3.3 V / 3.35-12V 5 V / 5-12 V	8 MHz 16 MHz	6/0	14/6	0.512 1	1 2	16 32	×
Micro	ATmega32U4	5 V / 7-12 V	16 MHz	12/0	20/7	1	2.5	32	○
Mega 2560	ATmega2560	5 V / 7-12 V	16 MHz	16/0	54/15	4	8	256	○
Gemma	ATtiny85	3.3 V / 4-16 V	8 MHz	1/0	3/2	0.5	0.5	8	○
LilyPad	ATmega168V ATmega328P	2.7-5.5 V 2.7-5.5 V	8MHz	6/0	14/6	0.512	1	16	×
LilyPad SimpleSnap	ATmega328P	2.7-5.5 V	8 MHz	4/0	9/4	1	2	32	×
LilyPad USB	ATmega32U4	3.3 V / 3.8-5 V	8 MHz	4/0	9/4	1	2.5	32	○
101	Intel® Curie	3.3 V/ 7-12V	32MHz	6/0	14/4	-	24	196	○
MKR1000	SAMD21 Cortex-M0+	3.3 V/ 5V	48MHz	7/1	8/4	-	32	256	○
Zero	ATSAMD21G18	3.3 V / 7-12 V	48 MHz	6/1	14/10	-	32	256	○
Fio	ATmega328P	3.3 V / 3.7-7 V	8 MHz	8/0	14/6	1	2	32	○
Mini	ATmega328P	5 V / 7-9 V	16 MHz	8/0	14/6	1	2	32	×
Nano	ATmega168 ATmega328P	5 V / 7-9 V	16 MHz	8/0	14/6	0.512 1	1 2	16 32	○
Ethernet	ATmega328P	5 V / 7-12 V	16 MHz	6/0	14/4	1	2	32	○
BT	ATmega328P	5 V / 2.5-12 V	16 MHz	6/0	14/6	1	2	32	×
Esplora	ATmega32U4	5 V / 7-12 V	16 MHz	-	-	1	2.5	32	○
Leonardo	ATmega32U4	5 V / 7-12 V	16 MHz	12/0	20/7	1	2.5	32	○
Mega ADK	ATmega2560	5 V / 7-12 V	16 MHz	16/0	54/15	4	8	256	○
Yùn	ATmega32U4AR9331 Linux	5 V	16MHz 400MHz	12/0	20/7	1	2.5 16 MB	32 64 MB	○
Due	ATSAM3X8E	3.3 V / 7-12 V	84 MHz	12/2	54/12	-	96	512	○