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DEVELOPMENT OF A CONTROL DEVICE AND ALGORITHM FOR AUTONOMOUS-MOVING SYSTEMS

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Abstract: *The article is devoted to improving the control and algorithm for Autonomous moving systems. The function of the controller is to provide communication between the control computer and the actuator. The ATmega2560 microcontroller is selected as the main processor. The electrical diagram of additional devices of the microcontroller is formed. Printed circuit boards consisting of separate blocks are made on the basis of the electrical circuit. To exchange information with external systems and process the received data, a special algorithm for the microcontroller has been created. The microcontroller is programmed based on this algorithm. The analysis of the functioning of the management system is performed, conclusions and recommendations are given.*
Keywords: *Autonomous-moving systems, Microcontroller, Electrical circuit, Printed circuit board(PCB), Input channels, Analog output blocks, Digital output blocks, Pulse wide modulation (PWM), Serial port, RS-232, Control algorithm.*

Аннотация: *Автоном ҳаракатланувчи тизимлар учун бошқариш қурилмаси ва алгоритмини такомиллаштириш кўриб чиқилган. Бошқариш қурилмасининг вазифаси бошқарувчи компьютер ҳамда ижро механизмлари ўртасидаги боғланишни таъминлашдан иборат. Асосий процессор сифатида ATmega 2560 микроконтроллери танланган. Микроконтроллерга қўшимча қурилмаларнинг уланиш электр схемаси шакиллантирилган. Электр схемаси асосида алохида-алохида блоклардан таркиб топган босма платалар ясалган. Ташқи тизимлар билан ахборот алмашиниш ва қабул қилинган ахборотларни қайта ишлаш мақсадида микроконтроллер учун махсус алгоритм яратилган. Микроконтроллер шу алгоритм асосида дастурланган. Бошқариш тизимининг ишлаш жараёни таҳлил қилиниб, хулоса ва тавсиялар берилган.*
Таянч сўзлар: *автоном ҳаракатланувчи тизимлар, микроконтроллер, электр схема, босма плата, кириш каналлари, аналог чиқиш блоклари, рақамли чиқиш блоклари, кенглиги ўзгарувчан пульс (КЎП) модуляцияси, кетма-кет порт, RS-232, бошқариш алгоритми.*

Аннотация: *Работа посвящена улучшению управления и алгоритма для автономных движущихся систем. Функция контроллера заключается в обеспечении связи между управляющим компьютером и исполнительным механизмом. В качестве основного процессора выбран микроконтроллер ATmega 2560. Сформирована электрическая схема дополнительных устройств микроконтроллера. На основе электрической схемы изготовлены печатные платы, состоящие из отдельных блоков. Для обмена информацией с внешними системами и обработки полученных данных создан специальный алгоритм для микроконтроллера. Микроконтроллер запрограммирован на основе этого алгоритма. Выполнен анализ функционирования системы управления, даны выводы и рекомендации.*
Ключевые слова: *Автономно - движущихся система, Микроконтроллер, Электрическая схема, Печатная плата (ПП), Входные каналы, Блоки аналогового выхода, Блоки цифрового выхода, Широтно-импульсная модуляция (ШИМ), Последовательный порт, RS-232, Алгоритм управления.*

Introduction. Nowadays, most processes are automated but almost all processes require direct human involvement. The main manager of any complex equipment and vehicles is a human. A person must work as much time with this system as how much time a technical system works. It may not be so difficult in mild conditions, but managing various technical systems in mines, oil production and in such difficult conditions can be a problem for people. Therefore, the world's leading institutes and research centers conduct various researches on the creation of autonomous - moving systems.

The class of autonomous controlled systems includes all means that can be moved independently based on specific intelligent programs without human intervention. Research on the development of autonomous controlled systems began in the 1980s. The objects of research in this area were cars, trucks, agricultural machinery, vehicles for the military industry, autonomous-moving vehicles in stores and warehouses [1]. The world's largest companies are engaged in the production of unmanned cars. In particular, General Motors, Ford, Cadillac, Mercedes Benz, Volkswagen, Audi, BMW, Toyota and a number of companies from China, France and the UK are conducting intensive research and investing more in this field. The main problems in this research field are fast measuring instruments, high-precision actuators and complex control systems. Autonomously - moving control systems are mainly uses for the following purposes:

- Transportation of goods in dangerous conditions, delivery of essential goods during natural disasters;
- Processing cultivated area in agricultural field;
- Releasing people from driving vehicles on a certain path;
- Decreasing the cost of production processes
- Optimal using of vehicles and etc.

This work will be dedicated to improving the control systems of autonomous - moving systems.

Degree of knowledge of the problem. Although automatic control systems are implemented in some traffic control tasks, the problem of full control is still unresolved. There are several software and technical factors:

Firstly, low measurement accuracy: satellite measurement systems make certain errors depending on the location of the object. Tall buildings, trees, high voltage power lines often interfere with measurements.

Secondly, the measurement speed is insufficient: data from the satellite system does not always arrive smoothly, so it may take some time to process them. On objects moving at high speed, even a short delay time can significantly affect the measurement system.

Thirdly, the lack of a universal management program: Scientists working in this field are trying to keep their programs as secret as possible, using algorithms that anyone can imagine. This leads to the absence of generally accepted standard methods and calculation algorithms.

Fourth, the high demand for enforcement mechanisms: When turning a technical vehicle in one direction to another, it is necessary to ensure "smooth movement". How smoothly the direction of movement of the car changes, it takes so much time to fix the control error.

Based on the foregoing, it is advisable to use simple systems, taking into account delays in the design and measurements.

Hardware part of the control devise. The control devise is consists of two parts: hardware and software. The hardware parts includes main processor, digital input-output blocks, analog input-output blocks, power supply and step motor driver.

As a main processor used Atmega2560. The ATmega2560 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega2560 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers[2] Fig.1.

The ATmega2560 provides the following features: 256K bytes of In-System Programmable Flash with Read-While-Write capabilities, 4K bytes EEPROM, 8K bytes SRAM, 86 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), six flexible Timer/Counters with compare modes and PWM, 4 USARTs, a byte oriented 2-wire Serial Interface, a 16-channel, 10-bit ADC with optional differential input s with programmable gain, programmable Watchdog Timer with Internal Oscillator, an SPI serial port, IEEE std. 1149.1 compliant JTAG test interface, also used for accessing the On-chip Debug system and programming and six software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or Hardware Reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except Asynchronous Timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the Crystal/Resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption. In Extended Standby mode, both the main Oscillator and the Asynchronous Timer continue to run. The ATmega2560 AVR is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, in-circuit emulators, and evaluation kits[2].

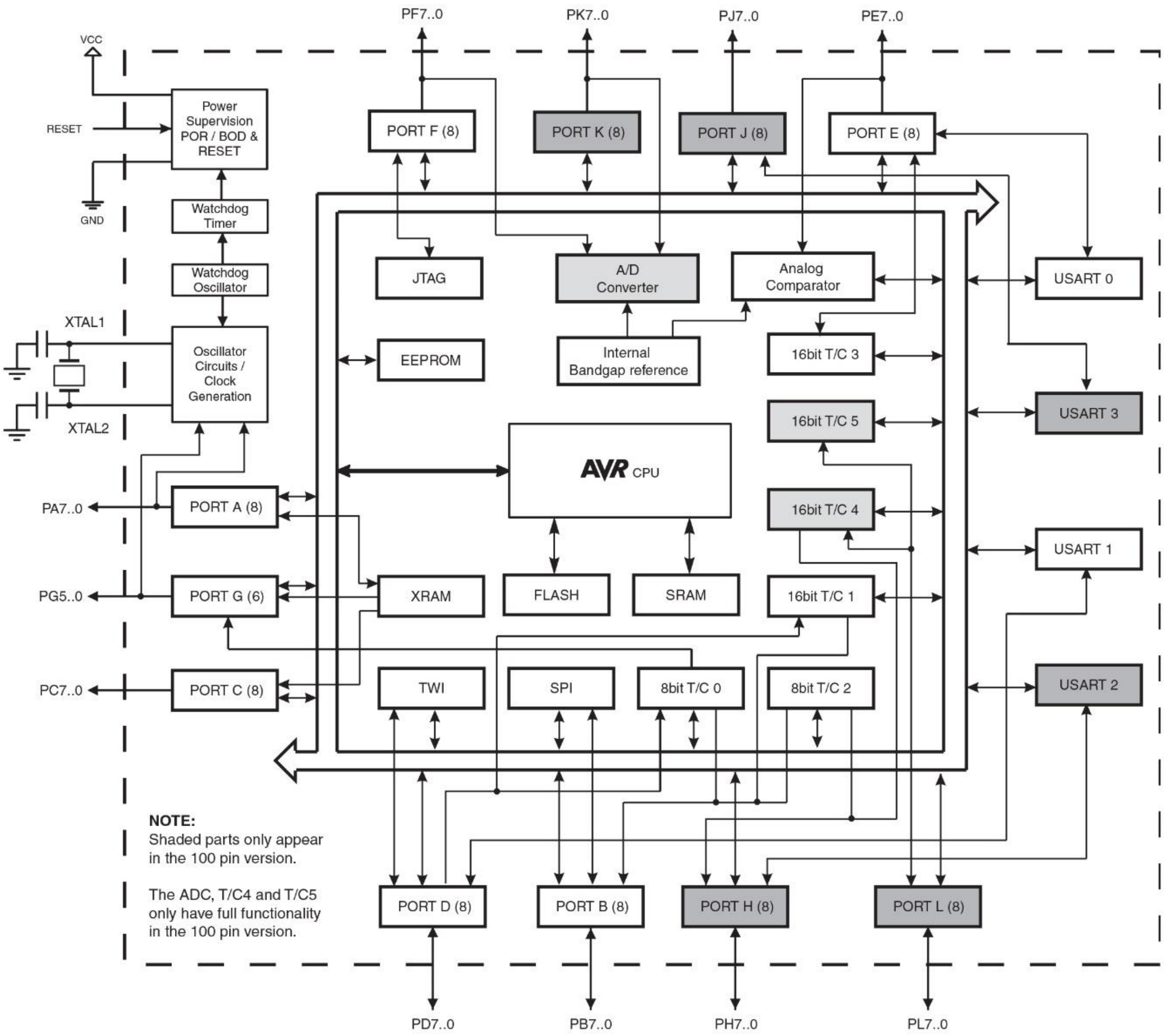

Fig. 1. ***Block Diagram of Atmnega2560 microcontroller.***

The digital input unit consists of several resistors and an optocoupler. The input signal for the digital input module is 24 V DC. To change the input signal level from 0-24 V to 0-5 V. An optocoupler was used. The electrical circuit of the discrete input module is shown in Figure 2.

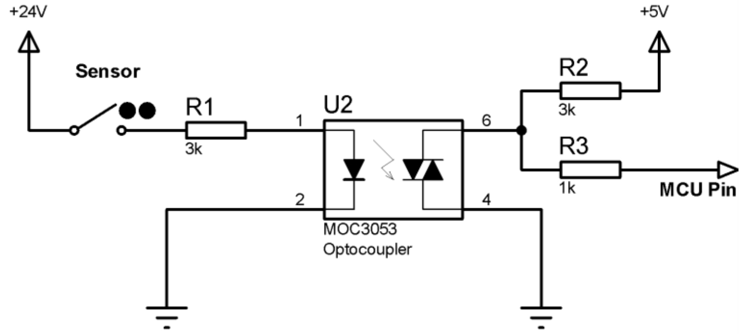

Fig. 2. ***Circuit of Digital Input unit.***

The optocoupler has two functions in this circuit. The first is the change in signal level, and the second is the protection of the input channel of the microcontroller at high voltage. The signal to the discrete input channel is transmitted through discrete sensors. When the logical one signal enters this channel, the controller receives the logical zero.

The digital output unit also consists of optocouplers, resistors, and a transistor S8050 n-p-n type (Fig.2.).

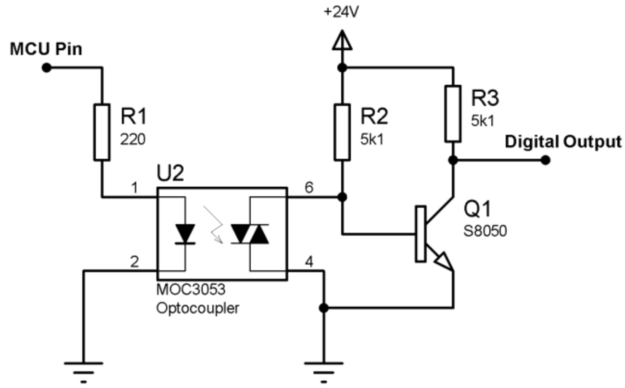

Fig. 3. ***Circuit of Digital Output unit.***

This circuit works in this way: when the microcontroller issues a logical one, the optocoupler will be open, and the key transistor will be closed. When the key transistor is closed, the digital output will be a logical one.

The controller is capable of receiving 10-bit analog signals in the range of 0-5V. To change the range of the 0-10 V signal from analog sensors used a voltage divider (Fig.4.). This circuit allows to change the input signal without delay.

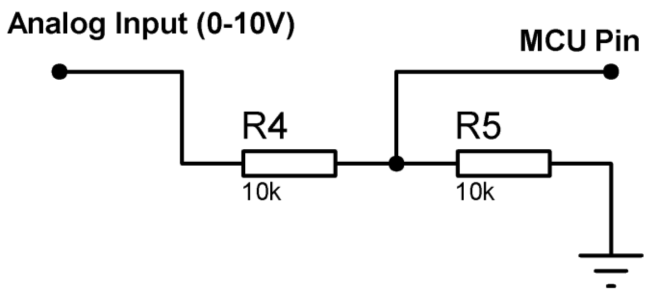

Fig. 4. ***Circuit of Analog Input unit.***

The analog output of the microcontroller is PWM. To control the playback mechanisms, have to change PWM signal to a DC signal. For this, the following circuit is used (Fig. 5). The analog output unit consists of MOSFET transistors, resistors and capacitors.

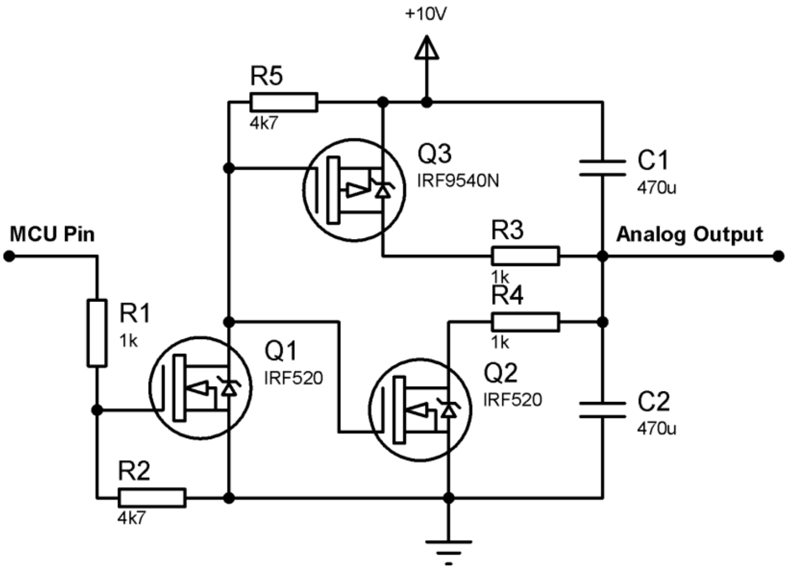

Fig. 5. ***Circuit of Analog Output unit.***

The analog output signal from this unit's microprocessor is PWM. Since PWM is a pulsed discrete signal, it is converted to an analog signal. This transformation requires a certain time. Dynamic characteristic of the analog output channel when ordered to change the value is as follows (Fig.6).

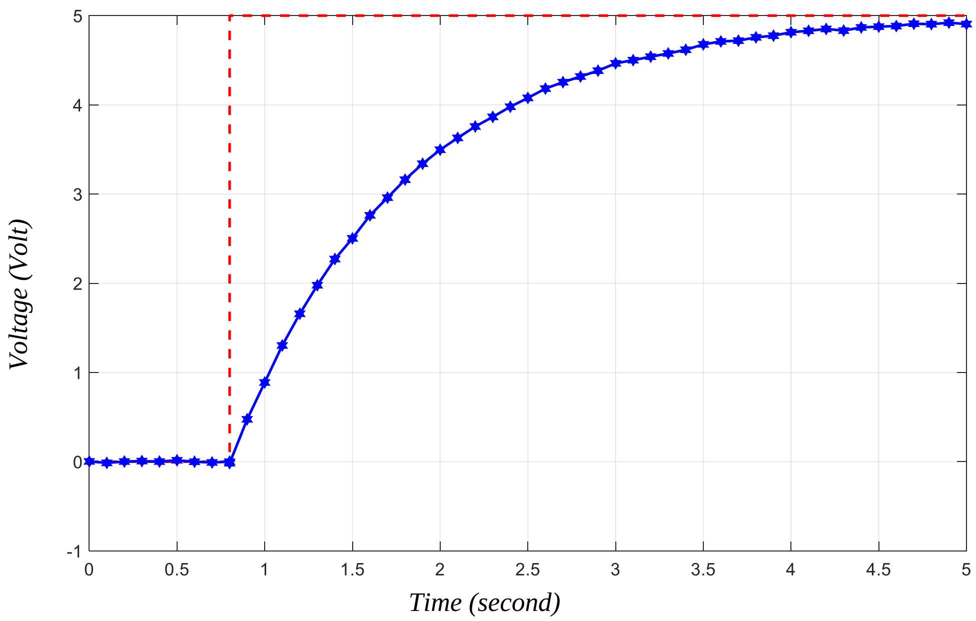

Fig. 6. ***Dynamical characteristic of analog output channel.***

In the calculations, the block of the analog output signal can be expressed as a first-order operiadic link without delay. It will looks like this:

$$W(s) = \frac{k}{Ts + 1}$$

k - gain, T - constant time of the object.

To support high-voltage connections by a control device, it is equipped with a relay-output unit (Fig. 7). These output channels are used to connect high-voltage networks at low speeds.

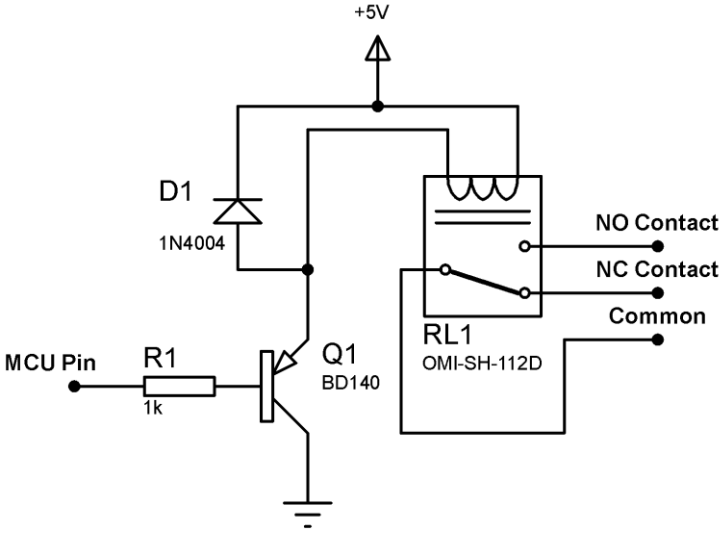

Fig. 7. ***Circuit of Relay-Output unit.***

The general functional diagram of the equipment is shown in Figure 8. It works as follows. When the system is connected to the source the first time the microprocessor assigns input and output channels once. The default values for the analog and digital outputs are zero. Then the processor reads the value of the discrete and analog inputs. Then it reads the serial port. By the command that comes from the serial port assigns the values of discrete and analog outputs. Then sends information about the status of the inputs on the serial port. This cycle is repeated until the power source is turned off.

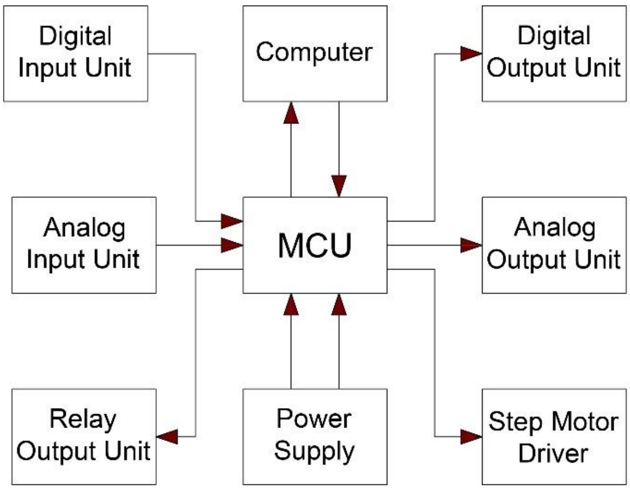

Fig. 8. ***Functional Scheme of Devise.***

Software part of the control devise. Any serial port terminal can control the device. Several commands have been developed to read the state of the digital and analog ports and write values to them. In order to read state of digital Input channel have to read following command: "IX".

“I” means indicator digital input. “X” means number of input channel.

Use the "OX" command to write a value to the digital output channel. Here is “O” means digital output, “X” is value of that output which can only accept 0 or 1.

The "AX" command is used to read the value of the analogue input channel. Just like the one above "A" means analog channel, and "X" means number of channel. To write a value to the analog output channel, the "BX" command is sent. In this case, "B" represents the analog compression channel ID, and "X" represents the output channel number. The device software performance algorithm is shown in Fig. 9.

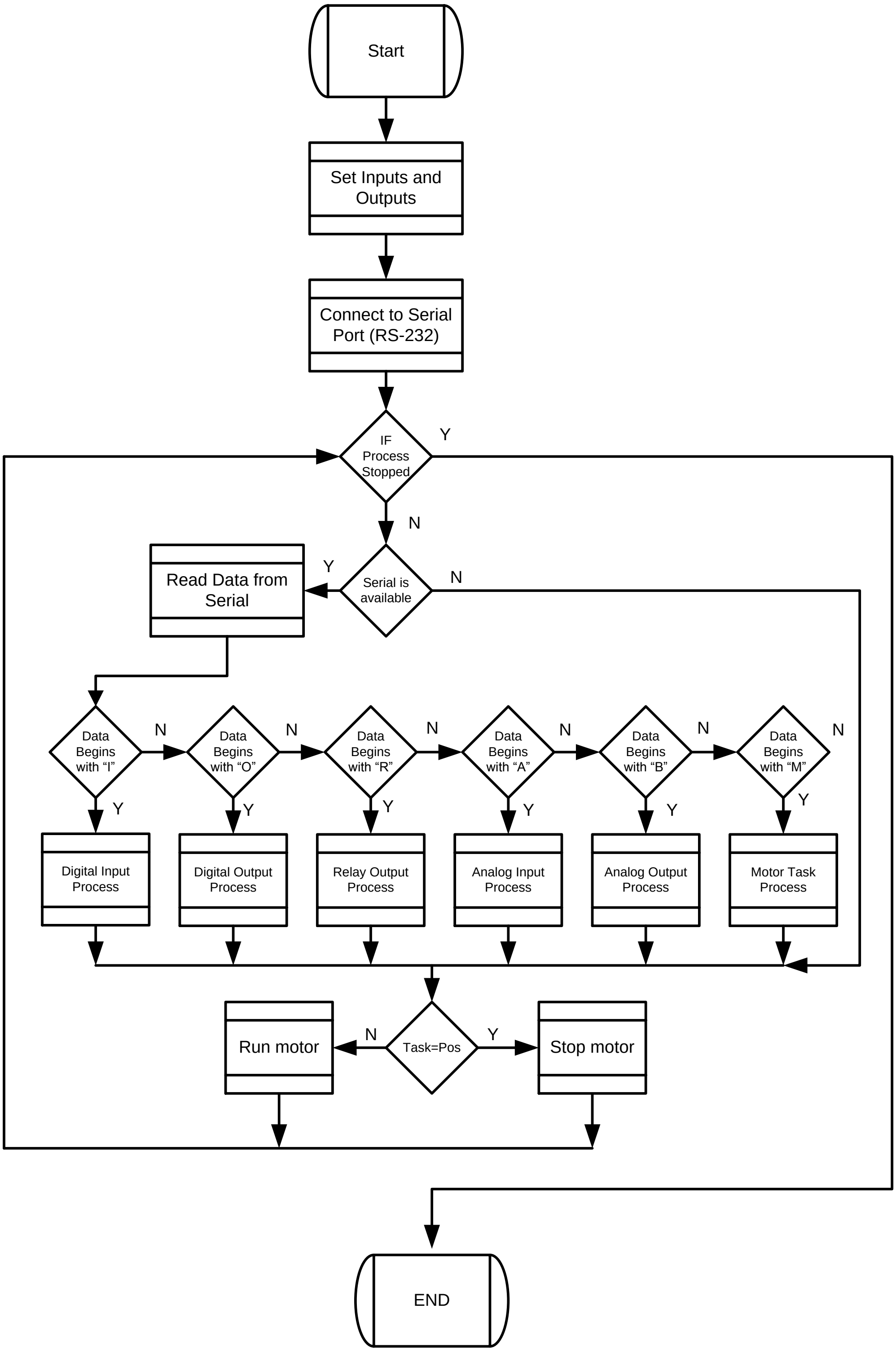

Fig. 9. ***The device software performance algorithm.***

Summary

A control device for autonomous moving systems has been developed. This device is connected to a PC via RS-232 and provides information exchange. Allows you to create a control system using any programming language. This allows the use of object-oriented programming languages to control autonomous moving systems. Device I / O channels consist of separate blocks, which can be easily replaced by blocks when a channel malfunctions.

The small number of elements used in the device makes it very reliable. And, of course, production will become a major factor in the low cost of production.

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