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Multi-Core Embedded Systems

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Abstract Paper deals with embedded systems, which are included into many products. These products achieve intelligence functions and properties. Microcontroller is as low cost embedded system and it is almost every time hidden in product and normal user never sees it. Possibilities of microcontroller are limited, but there is a possibility to make group of microcontrollers and many tasks can be divided between these microcontroller. It is something like computer network and controllers can cooperate with each other.

Keywords: *embedded systems, microcontroller, communication, interface*

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1. Introduction

Each of us likes the smart product with intelligence functions. These products help us with many activities in our life. The heart of these products is embedded system. That is controller which receives commands from user and signal from sensor and makes the decision about other activities through the actuators. Microcontroller is best solution, because of its low price. It has miniature dimensions what enables to insert into normally used things (glasses, watches, pen, vacuum cleaner, grass-mower, shoes, skis, bicycle, etc.).

Abilities of microcontroller is limited to several input-output pins, limited amount of memory, limited instructions per second, limited simultaneously running processes etc. That is the reason of making the groups of microcontroller. All activities can be divided between these microcontrollers and system is faster than with one microcontroller. Also it is possible to make redundancy system with increased safety. It means that it is possible to develop product with self testing, self diagnostic, self repairing, reconfigurable system, multitasking in real time and other activitites which are too many for one microcontroller. This is reason why microcontrollers are grouped together in one product.

Automotive industry is perfect place for using of embedded systems. The first electronic pieces were used to control engine functions and were referred to as engine control units (ECU). As electronic controls began to be used for more automotive applications, the acronym ECU took on the more general meaning of "electronic control unit", and then specific ECU's were developed. Now, ECU's are modular. Two types include engine control modules (ECM) or transmission control modules (TCM). A modern car may have up to 100 ECU's and a commercial vehicle up to 40. Car has many independent functions and automotive electronics or automotive embedded systems are distributed multi-core systems, and according to different domains in the automotive field, they can be classified into: engine electronics, transmission electronics, chassis electronics, active safety, driver assistance, passenger comfort, entertainment systems etc [1,2].

Finally the automotive industry is still under the development and result of embedded systems including is the driver-less cars.

The structure of microcontroller group in product is depends on number of independent functions and properties of product (Figure 1).

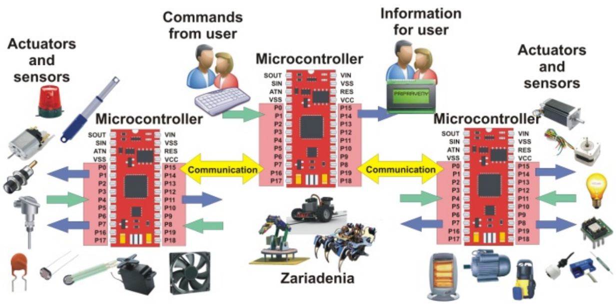

Figure 1. Multi-core embedded systems

One of our embedded systems project is puck collecting robot for robotic competition Robot Challenge. Competitive robots have to collect small discs ("pucks") on the field according to color. To robots compete against each other on a 250 x 250 cm field. The aim is to collect all pucks of the assigned color and carry them to the own home base. The first robot which collects all the assigned pucks wins. The puck collecting robot includes two-core embedded system, because of need to execute many activities in real time.

Figure 2. Puck collecting robot

Structure includes two microcontrollers: locomotion microcontroller and puck handling microcontroller. Locomotion microcontroller obtains signals from infrared distance sensor, from collision bumper touch sensors and from ultrasonic distance sensors. On the base of these sensors, locomotion microcontroller plans next locomotion and control it through drives of both wheels. These sensors enable to recognize, where the other rival robot is and where these assigned pucks are. It means that robot is still looking for assigned pucks and it avoids the rival robot. Puck handling microcontroller (Figure 3) receives information about the puck color and then it is able to sort the selected color pucks. Puck handling microcontroller also receives information about the actual ground color under the robot (if it is home base or no). If robot is above the home position, puck handling microcontroller decides for unloading of collected assigned pucks.

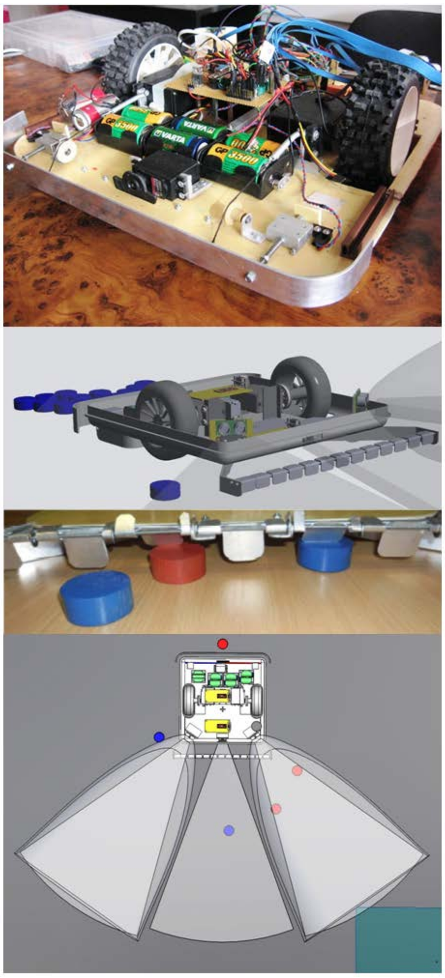

Figure 3. Embedded systems in puck collecting robot

2. Communication Network

Main task is to compose the communication between microcontrollers for fast executing of processes. Safety communication is the first mainly in product, where human life is taking into account. Binary signals is frequently used for reduction of noise and fast data transfer. Communication net in multi-core embedded systems can be realized also with pulse width modulation signals PWM (Figure 4). Also many sensors and actuators use the PWM signal for data transfer. Disadvantage of this concept is limited number of controllers.

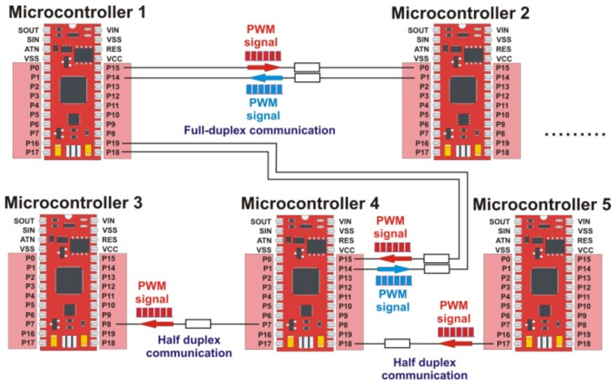

Figure 4. Microcontrollers communication net with PWM

Also standard serial or parallel communication (Figure 5) is used in multi-core embedded systems between microcontrollers. Serial communication is frequently used, but parallel communication takes many pins and wires and it is used only for some of LCD displays.

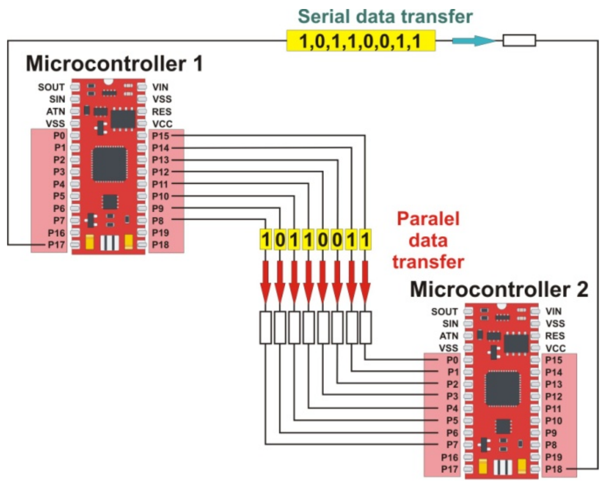

Figure 5. Serial and parallel transfer of data

Many serial communication systems were originally designed to transfer data over relatively large distances through some sort of data cable. The term "serial" most often refers to the RS232 port on the back of the original IBM PC, often called as serial port.

Many variations of serial communications are used for microcontrollers: RS-232 (probably the most ubiquitous of all serial ports), RS-485, RS-422, UniversalSerialBus (USB), I2C (also IIC, InterIntegratedCircuit) Bus, Ethernet, PS2, FireWire IEEE 1394, CAN bus, SPI etc.

Holder if information is logical levels “0” and “1”, which can be realized for every type with different values of voltage (Figure 6). Microcontrollers frequently use TTL logic at all pins and some of the pins use also inverted logic RS-232 and I2C logic (Figure 6).

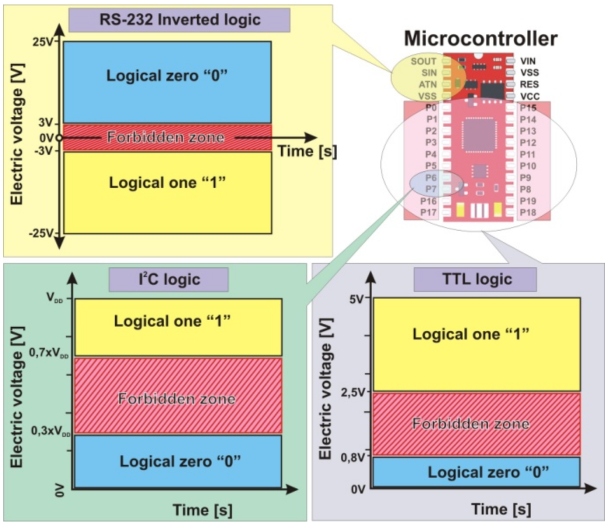

Figure 6. Voltage value for logical levels of various types of communications

Serial communication RS-232 has different logical levels as the TTL logic and if there is a need to connect two controllers via using these different signals, there is a possibility to use the converter of logical levels as MAX232 or similar (Figure 7) [3,4].

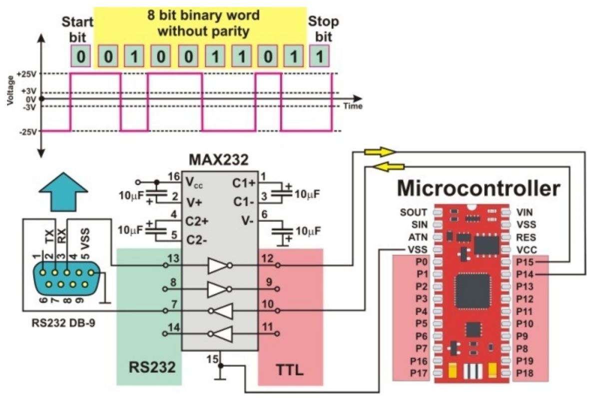

Figure 7. RS232 to TTL and vice-versa conversion

3. Serial Communication

Mechatronic systems are become more complicated and they includes many sensors and actuators and others devices also microcontrollers. There is a need of fast communication with large amount of data transfer.

I2C (Inter-Integrated Circuit) is serial bus (Figure 8) developed by Philips Semiconductor company in year 1980 primarily for communication between devices placed on one printed circuit boards with minimum numbers of pins. This bus uses synchronous serial type of communications with half duplex mode. Topology of this bus is based only on three wire: data wire (Serial Data - SDA), synchronous wire (Serial Clock - SCL) a common ground. Every device connected to I2C bus is identified via using the unique address. Both wire SDA and SCL is connected to power supply voltage through the pull-up resistors and every device is able to pull down this link to logical zero via using the open collector transitor. Maximum data transfer is limited with frequency of synchronization pulses on SCL wire. Maxim transfer rate can reach 3,4 Mbit/s. It is necessary to transfer data and also address of target device and requirement for writing, reading or confirmation about ready device for receiving of data and also start and stop bit [5].

This type of bus allows to connect microcontrollers, sensors, actuators, LCD panels, memory and other devices in to only two data wires (Figure 8).

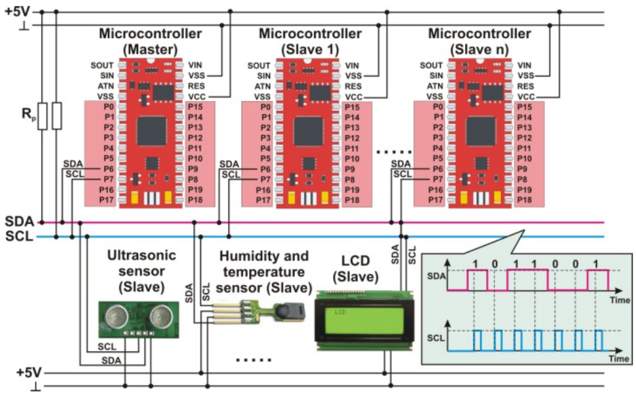

Figure 8. I2C communication in multi-core embedded systems

Other possibility is communication through the 1-Wire® bus also known as MicroLAN™ (Figure 9). It was defined by Dallas Semiconductor company as communication bus between electrical devices. It uses the same logical levels as TTL logic. The topology of this bus consists of only one data wire and common ground [6].

This bus allows the half-duplex both side communications. The specific property is that data wire can be used also as power supply for connected devices. This bus allows connecting up to 1500 devices into only one-wire bus [6].

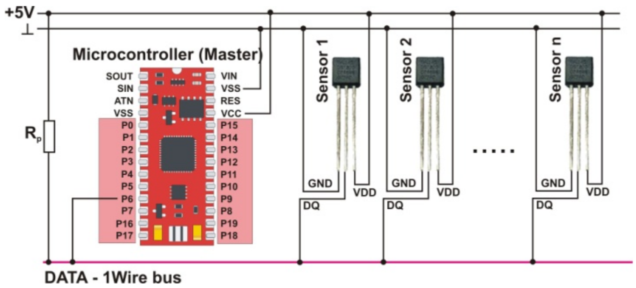

Figure 9. 1Wire communication in multi-core embedded systems

4. Conclusion

The didactic model of the 4floor lift is very similar to big real lift. It is necessary to processes more than 40 signals. It uses one master microcontroller and one slave microcontroller (Figure 10). Students can make training on this model for enlarging the knowledge and practical experience of students.

Two legged robot (Figure 11) needs the controlling and sensing of many signals. The structure of the robot consists of three TTL microcontrollers from various producers.

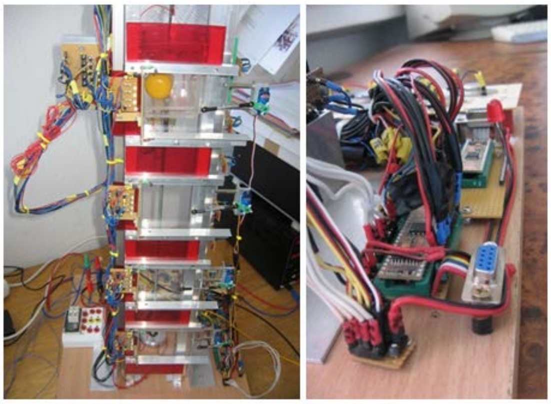

Figure 10. Applications with multi-core embedded systems – didactic model of the lift

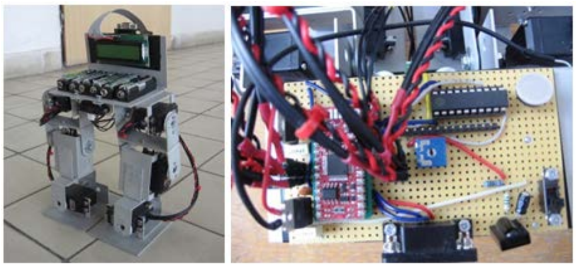

Figure 11. Applications with multi-core embedded systems – two legged robot

Many applications need to solve multi-core embedded systems composed from several pieces of microcontrollers. Multitasking and parallel processes required this type of embedded systems. Also number of obtained signals overcomes the possibility of one microcontroller. There is a place for distributed type of embedded systems. Also safety of mechatronic devices can be solved through this type of embedded system [7-27].

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