Sensoric subsystem of Automated guided vehicle
TCP communication between SIMATIC S7 PLC and Arduino

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ABSTRACT
The cheap work with high precision is very necessary in industry for a long time. Research in robotics gives us opportunity for development of automatically guided vehicle controlled by PLC, which can be easily used for supplement transport inside factory, or even for human transport. Main aim of this work is to show, how to replace expensive industrial sensors with integrated communication interface by simple cheap open-source technology. Our solution is focused on TCP communication between Arduino and PLC. The Arduino is extended to Ethernet shield. It makes possibility to connect third-party devices to PLC and save I/O PLC modules. The Arduino pre-process data from ultrasonic and line-following sensors and combine them into one data packet which is send over the network to PLC server.

INTRODUCTION
What is AGV?
• Automated guided vehicle (AGV) is a type of unmanned mobile vehicle designed primarily to carry material, tow objects behind them in trailer and also transport individuals.
• AGVs are commonly used in manufacturing plants, warehouses, distribution centers and terminals. For navigation, AGVs mostly use signal paths, lane signals or signal beacons.
• There are several main sensors that AGVs use for navigation, for example optical sensors, magnetic sensors, laser scanner and camera.
• When moving vehicles it is necessary to ensure the safety of the environment, personnel and the vehicle itself. The safety is ensured by the operation of sensors that detect obstacles and impeding danger in their path.
Our AGV is controlled by PLC SIMATIC ET200S and communicates via industrial wireless LAN with the use of PROFINET and PROFSAFE communication standards. Direct connection of third part systems through industrial Ethernet is easily implemented. This provides rapid exchange of data between peripherals and control system.

Arduino NANO & Automation technology?
• A lot of automation technology nowadays is controlled by embedded devices, like Arduino, Raspberry Pi, Cubieboard, etc. All named devices have same purpose and it is easier hardware and software programming.
• Difference between boards is in used microprocessors, data memory and number of interfaces.
• Different types are designed for education, designers, even artists.
• In our work we used Arduino Nano rev. 3.0, because of its small size, small power consumption and same hardware as the most worldwide used Arduino Uno, which includes same analog / digital inputs and outputs, PWM outputs and support more communication standards.
• Arduino doesn’t support 24V logic, we can easily find a lot of extension, like relays or connectors for industrial usage. In our solution is Arduino directly connected to five ultrasonic sensors and five line-following sensors. Our Arduino process data from sensors and combine them to one data packet. The Arduino usage saves peripheral inputs / outputs modules of PLC, which can be used for another application and extend availability to connect non-commercial sensors to PLC.

Safety movement - Ultrasonic sensor HC-SR04
• We used five HC-SR04 ultrasonic sensors for safety movement of AGV.
• Measurement range of these sensors is from 2 cm to 400 cm.
• Operating voltage is 5V and operating current is 15mA. Operating frequency is 40 kHz and angle range is 15 degrees. When 10 µs impulse is sent into Trigger input, module send node of 8 ultrasonic impulses to the space and Echo output is sent on logic 1. In this step module waits for reflected waves. When they arrive to sensor, Echo is set to logic 0. Time between logic 0 and logic 1 in Echo output is relative to distance from sensor to obstacle. In our project we use one shared digital output/input of Arduino for trigger and echo.

TCP COMMUNICATION

TCP CLIENT – ARDUINO NANO rev.3 & ETHERNET SHIELD ENC28J60
• Standard Arduino Ethernet Shield uses Wiznet5100 Ethernet controller, with <Ethernet.h> Arduino Library. Maximal network speed of Wiznet5100 controller is 100Mbit per second. Unfortunately, this Shield is tuned for bigger versions of Arduino, e.g., Arduino UNO, Mega, Duemilanove etc.
• We chose Ethernet Shield with ENC28J60 Ethernet controller, which isn’t compatible with <Ethernet.h> library included in Arduino IDE development environment.
• The ENC28J60 chip includes completely independent 10BASE-T Ethernet driver with SPI communication interface. The RJ-45 connector is used in 10BASE-T network. Maximal speed of this network is 10Mbit per second. The ENC28J60 Ethernet Shield power supply range is from +3.3V to 5V and is regulated by own power regulator. For Shield control we chose alternative <uIPEthernet.h> library, which is compact replacement for standard <Ethernet.h> library. Disadvantage of this library is bigger memory usage. For communication between Shield and Arduino are used SPI 10, 11, 12 and 13 pins. The pin 2 is used for interrupt signal.

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