WISM II Final Report

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1 Node Distributor Device: Case

The case is made with a 2 mm and 3 mm thick plastic and the maximum dimensions are 9.5 cm x 9.0 cm x 62.5 cm (width x height x length). **Figure 1** shows the case of the Node Distributor Device.

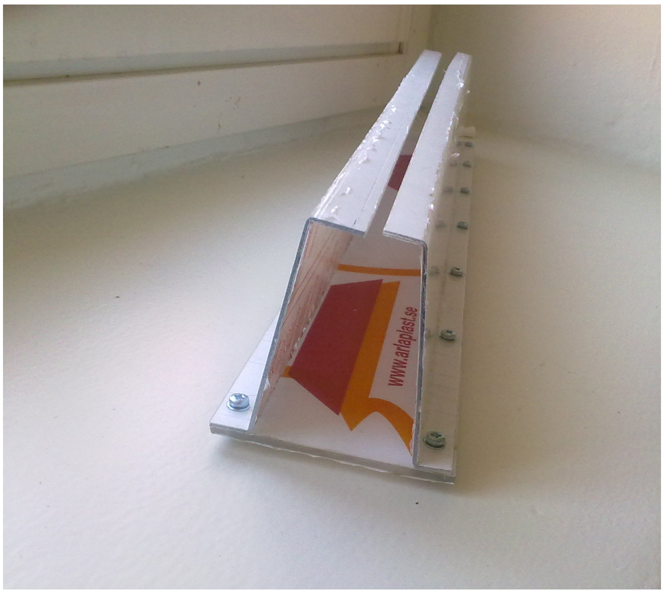


Figure 1. Case of the Node Distributor.

2 Node Distributor Device: Electronic Design

The electronic design has been done in the following steps. First it was analyzed what electronic components are already on the robot and how these components could be connected with the electronic of the Node Distributor Device. In the second step the decision has been made, if the process should be completely controlled by the Robot PC or if the Robot PC should send a start command to a slave device (microcontroller) that takes care of the whole node distribution process. The latter option has been taken because it simplified the electronic design. For the slave device the MSP430 Launchpad from Texas Instruments (TI) has been selected (see **Figure 2**).

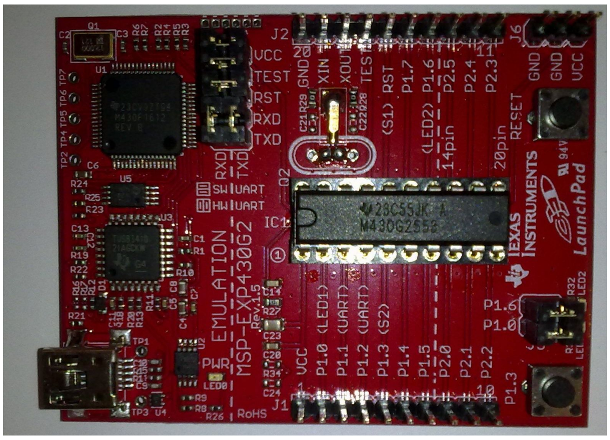


Figure 2. TI MSP430 Launchpad.

In the third step the general overview of the electronic design has been made.

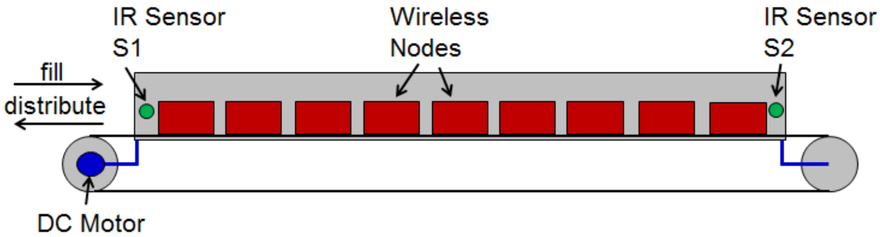


Figure 3. Conveyor with IR Sensors.

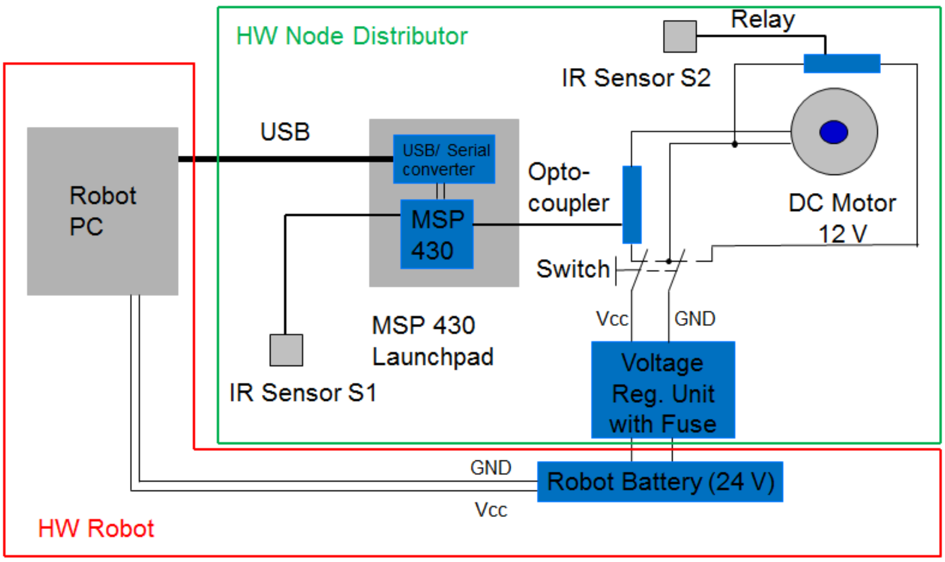


Figure 4. General Overview of the Electronic Design.

In **Figure 3** the conveyor with two IR Sensors is illustrated and in **Figure 4** a general overview of the electronic design is shown. The MSP430 Launchpad is connected via

Universal Serial Bus (USB) with the Robot PC and it receives its power from the Robot PC over USB. The IR Sensor (S1) is connected with the microcontroller and its task is to detect if a Wireless Sensor Node (WSN) has been dropped on the ground. IR Sensor (S2) stops the conveyor belt motor in the filling process when a WSN reaches the end of the conveyor. The power of the motor is taken from the robot's battery.

In the fourth step the required electronic components were selected.

Required components:

- Infrared Sensors (Receivers TSOP1738 and Transmitters LD271)
- Motor for conveyor belt (12V DC Motor from Bebek)
- Motor Control Unit (MCU)
- Voltage regulator

In the fifth step the required circuits were designed. First the circuits were built on a breadboard before they have been soldered on the Printed Circuit Board (PCB).

IR Sensor Circuit

One IR Sensor consists of two circuits, a transmitter circuit and a receiver circuit (see **Figure 5**). The IR Light-emitting diode (LED) is clocked by a 38kHz signal generated by the microcontroller (MSP430) so that the IR receiver (TSOP1738) can work smoothly.

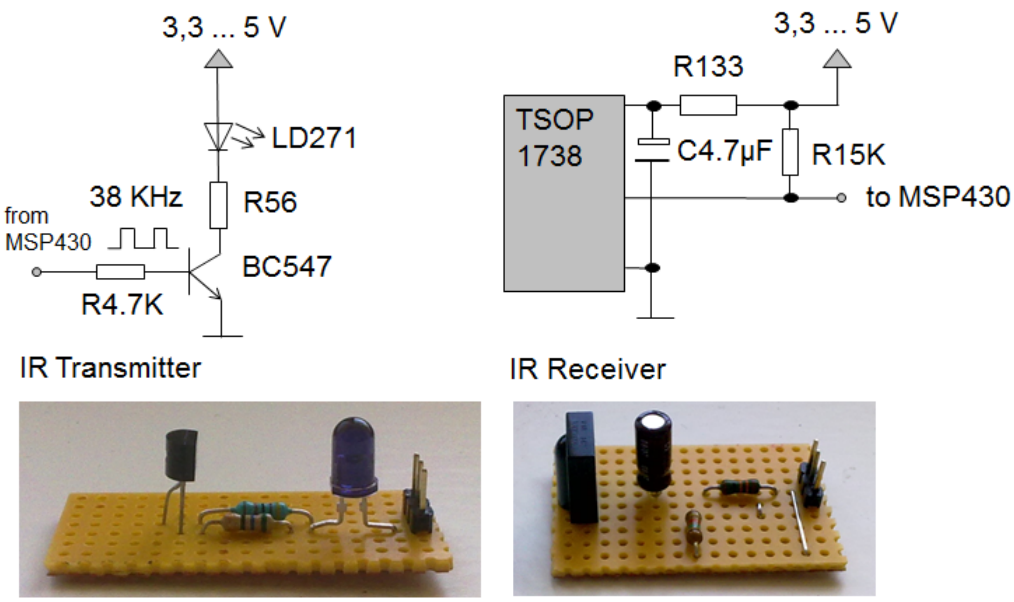


Figure 5. IR Sensor Circuit.

Optocoupler Circuit

The optocoupler circuit shown in **Figure 6** is connected with the MSP430 Launchpad. An optocoupler is used to achieve galvanic isolation between the MSP430 Launchpad circuit and the motor circuit. The maximum current consumption of the motor is according to the data sheet 400mA. Thus a transistor has been selected that can handle a collector current of 500mA. The motor has a strong torque and a low speed, hence no Pulse-width Modulation (PWM) is required. If a PWM is needed it would be better to replace the transistor (BC337) with a Metal-Oxide-Semiconductor Field-Effect transistor (MOSFET) to save power.

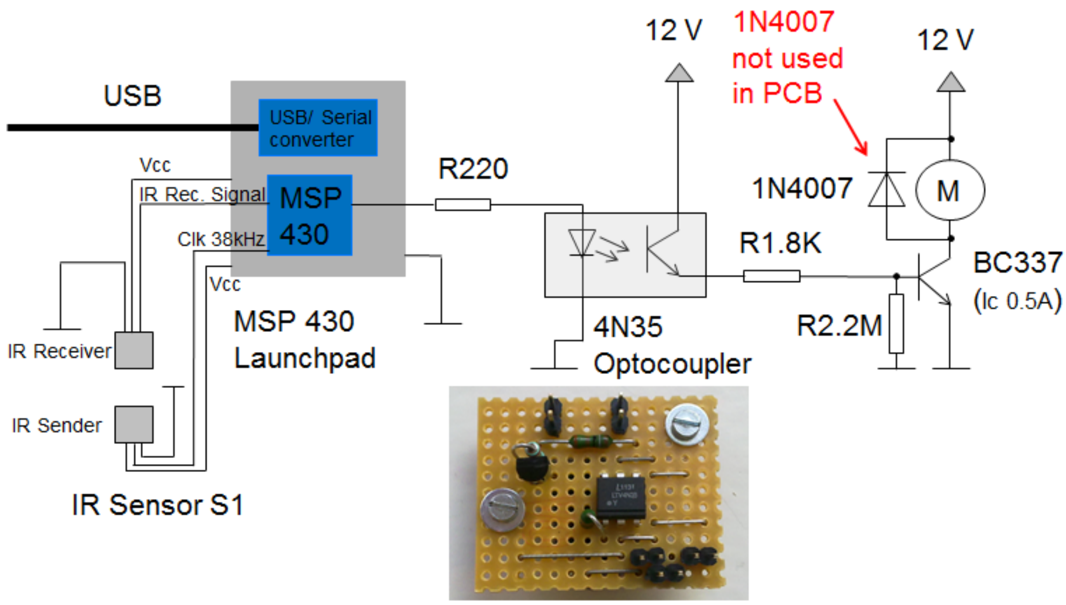


Figure 6. Optocoupler Circuit.

Relay Circuit

This circuit contains a relay that controls the motor circuit in the filling process (when the device is getting filled with WSNs).

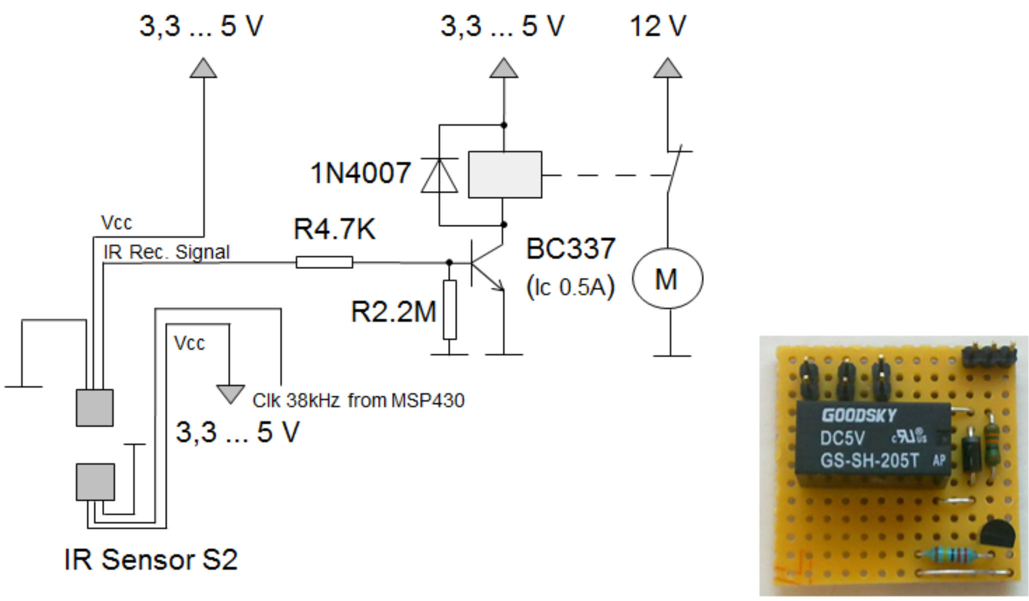


Figure 7. Relay Circuit.

Figure 7 illustrates the relay circuit. The motor stops when a WSN reaches the end of the conveyor belt (IR Sensor S2 is interrupted).

Electronic for the Motor Control

In **Figure 8** the whole electronic for the motor control is presented. There are two operation modes controlled by a switch. One mode is the run mode where the device waits for the start command sent from the Robot PC to distribute a WSN. The other mode is the filling mode where the device is filled with WSNs.

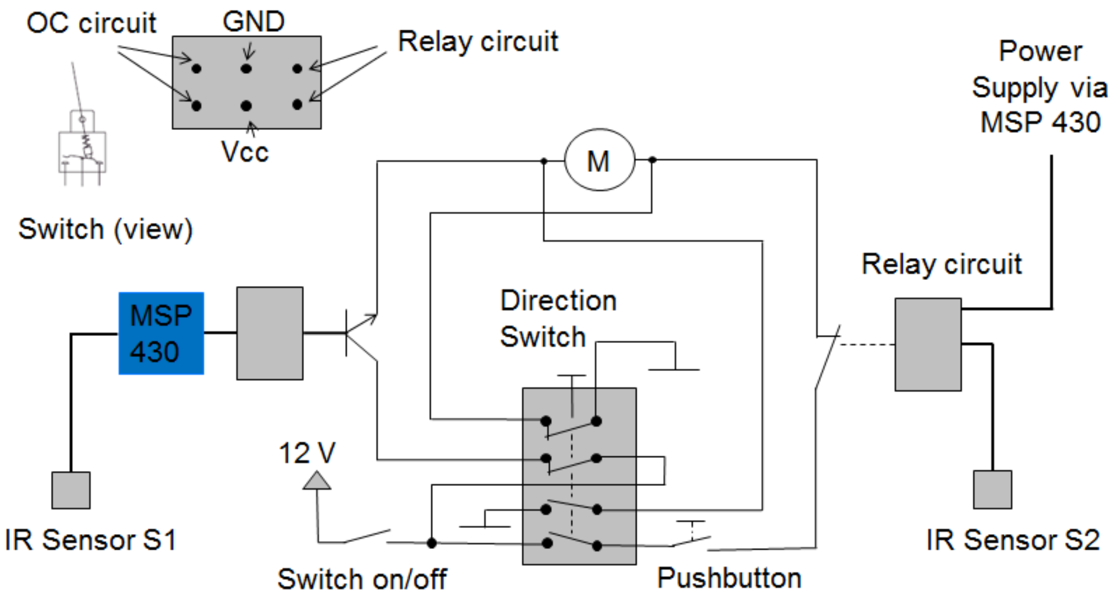


Figure 8. Electronic for the Motor Control.

3 Node Distributor Device: Software Implementation of the Microcontroller

The software for the microcontroller was written in C. The microcontroller is in low power mode until the start character is received. When the start character sent by the Robot PC is received the Interrupt Service Routine (ISR) of the Universal Asychronous Receiver Transmitter (UART) is called and the motor starts turning until a falling edge interrupt followed by a rising edge interrupt occurs on the microcontroller pin that is connected to the IR receiver of IR Sensor (S1). **Figure 9** illustrates two cases that had to be considered before the first node is dropped. In the first case the WSN already interrupts the IR Sensor while in the second case the WSN does not interrupt the IR Sensor. For that reason it is necessary to wait for a falling edge interrupt and then for a rising edge interrupt. A problem that had to be solved was how to stop the motor when the last WSN has been dropped. In order to avoid that the motor is continuously running a watchdog timer is used that stops the conveyor after 10s when no interrupt on the IR Sensor (S1) occurred before. Pulse-width Modulation (PWM) is used to generate the 38kHz signal for the IR LEDs. In **Figure 10** the general overview of the software implementation is shown.

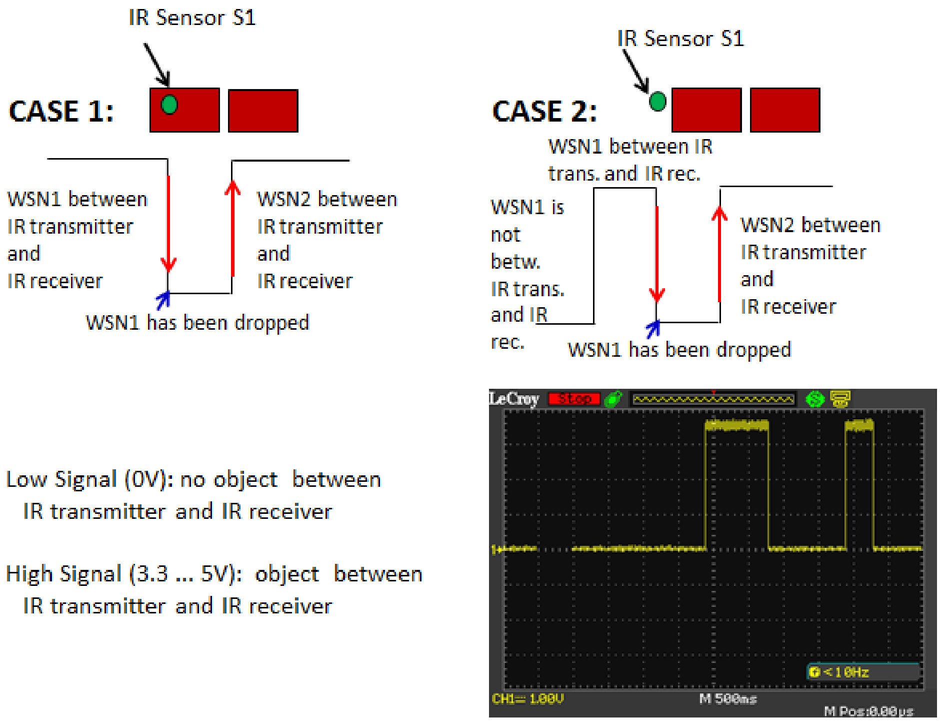


Figure 9. The two cases that need to be considered before the first node is dropped.

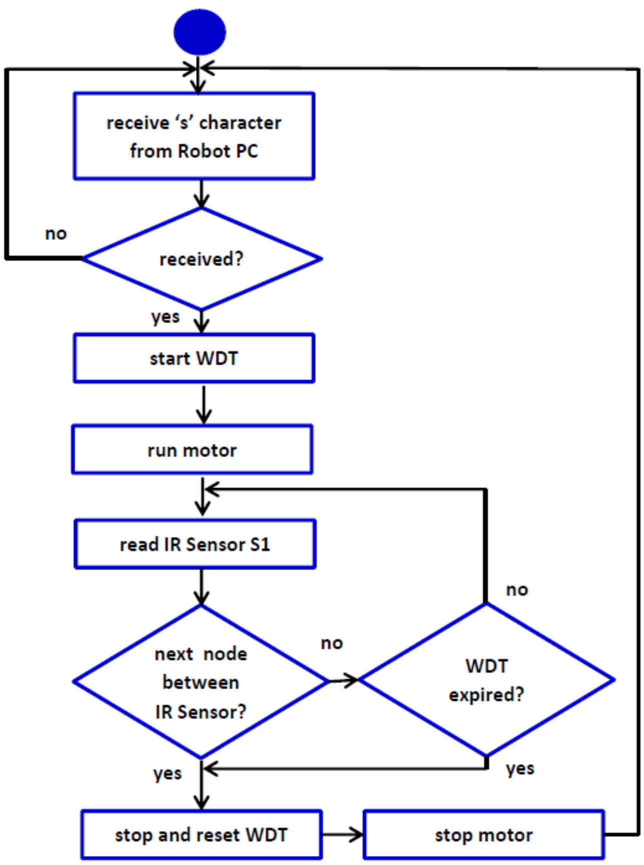


Figure 10. General Overview of the Software Implementation (MSP430).

4 Node Distribution

The dropping of a node is controlled by a Graphical User Interface (GUI). When the pushbutton on the GUI is clicked, or if a certain button of a connected joystick is pressed, then the Node Drop Publisher of the ICE STORM Server will receive a command to drop one WSN. This command will be forwarded to the ICE STORM Server and from there it will be forwarded to the Node Drop Subscriber running on the Robot PC. The Node Drop Subscriber will send the command over the USB connection to the microcontroller from where the node distribution process starts. Every time a node is dropped the timestamp will be saved, so that the odometer position can be determined. **Figure 11** gives an overview of how the current system works.

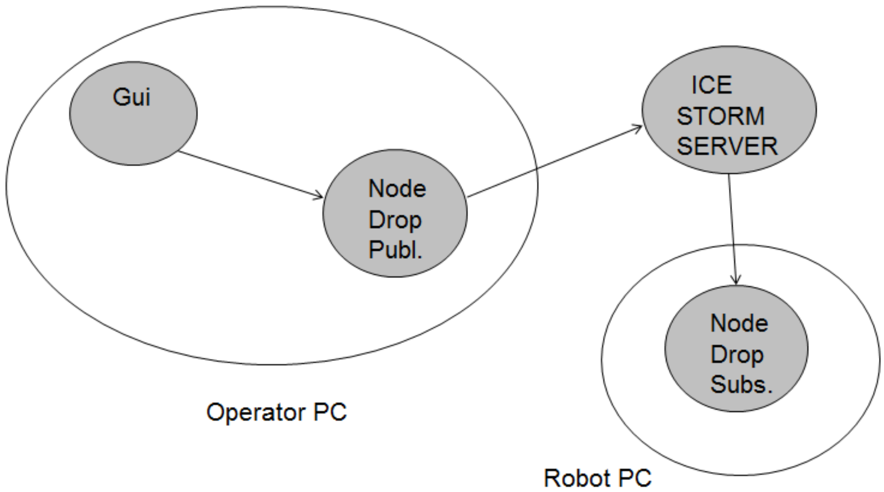


Figure 11. Overview of the current Node Distribution System.

5 Suggestion for the Node Distribution in the Future

The WSNs could be distributed in the following way. At the starting point the robot drops the first WSN on the floor and continues driving. During the drive the WSN mounted to the robot measures always the signal strength to the previous dropped WSN. After driving a certain distance the robot drops the next WSN on the floor when the signal strength to the previous dropped WSN is good enough. In order to determine the position at which the WSN is dropped, the odometer information of the robot could be used if it is accurate enough. This requires that the WSNs in the Node Distributor Device must be sorted, so that the WSN with ID1 is distributed first and the WSN with the highest ID is distributed at last.

Previous Received Signal Strength Indicator (RSSI) based distance measurements have shown (Glocker 2010) that the RSSI values for certain distances vary a lot in different environments. For that reason it is probably better to use the odometer information of the robot for determining the position of the WSNs rather as self localization over the network.

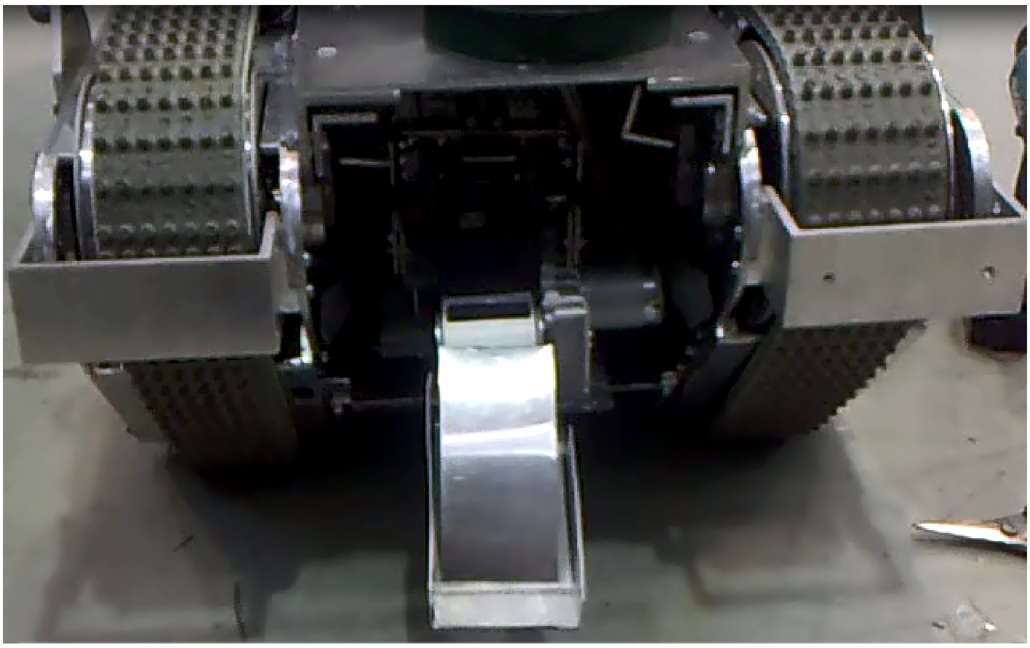
6 Acknowledgment

We would like to thank Markku Kuusinen and Jyrki Isoniemi for their assistance in the metal workshop and to Kumi-Järvinen Oy for making the belt of the conveyor. It is to mention that Markku Kuusinen has done the turning and the mounting of the conveyor belt wheel attached to the motor. We also would like to thank Jani Ahvonen for making the plastic wheels with the PCB making machine and the staff members (José Vallet, Tapio Leppänen, Jari Saarinen, Marek Matusiak, Matthieu Myrsky, Sami Kielosto) of the Automation Technology Department at Aalto University in Helsinki for the very good collaboration.

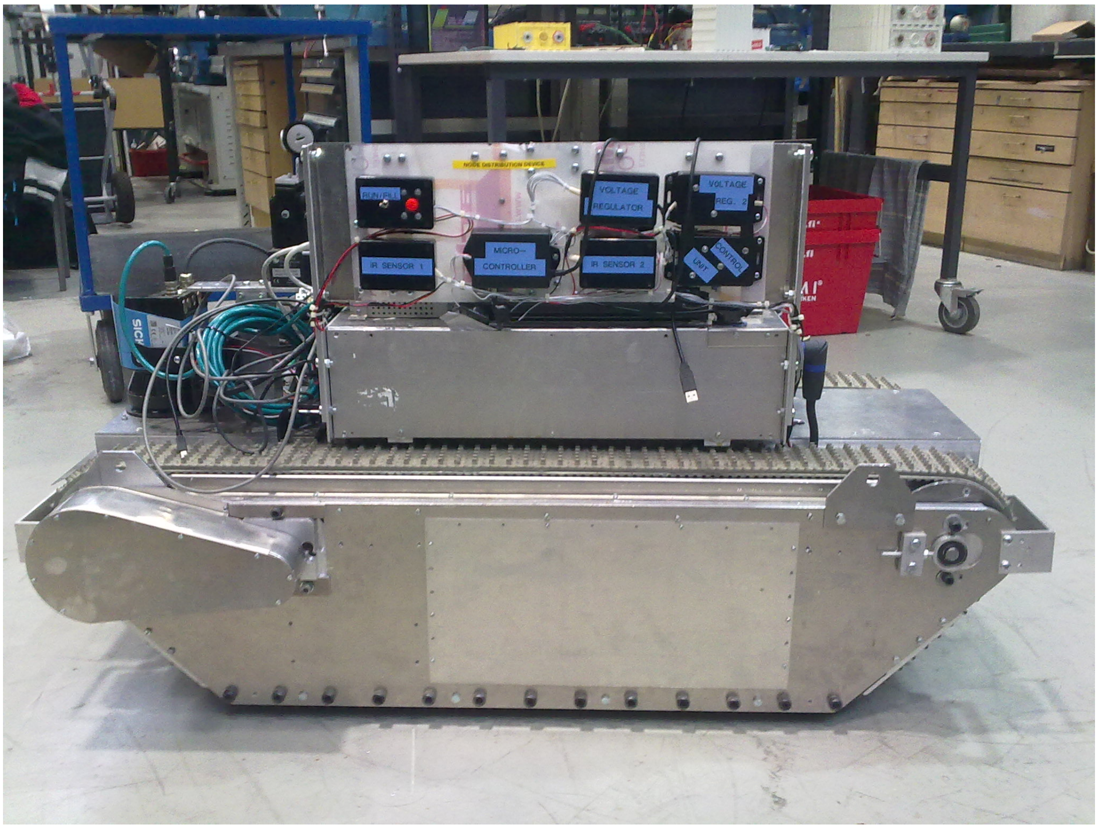
7 Bibliography

Glocker, Tobias (2010). Software and Hardware Design of a Miniaturized Mobile Autonomous Robot Operating in a Wireless Sensor Network. University of Vaasa.

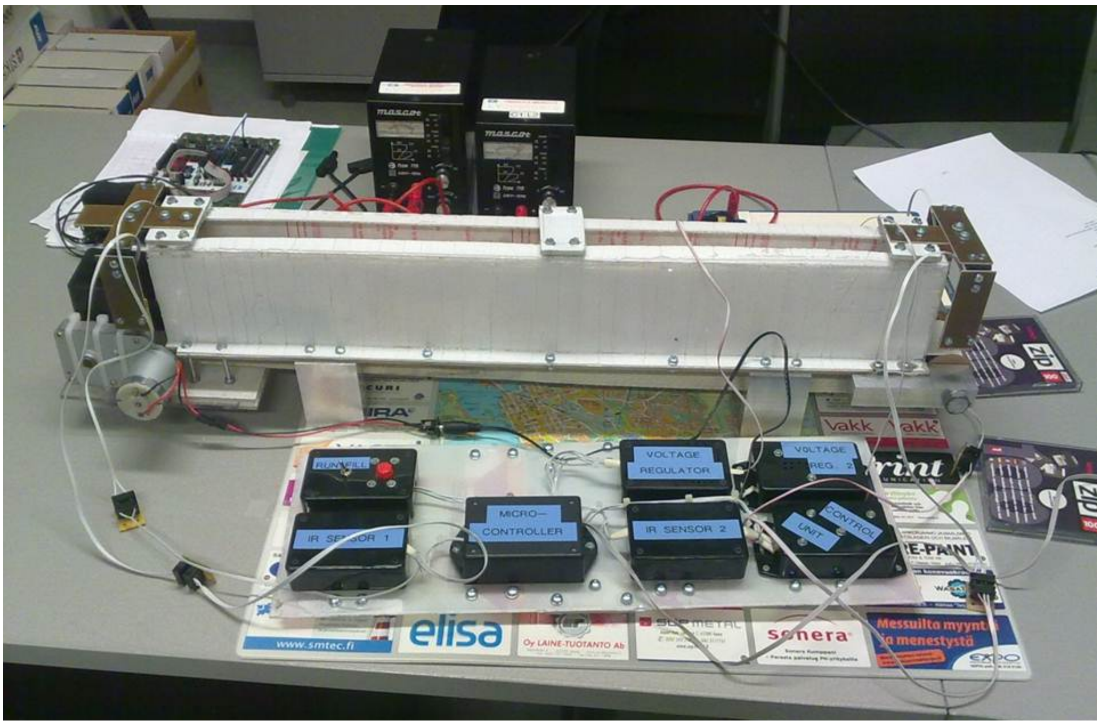
8 Pictures



Picture I. Robot with the Node Distributor Device.



Picture II. Robot with the Electronic Board for the Node Distributor Device.



Picture III. Node Distributor Device with the Electronic Board.