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Industrial Robot Label Applicator

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The thesis deals with a project carried out for developing and setting up a robot label applicator system. The requirement was that RFID tracking labels can be applied on flexible positions, without manual effort and rearrangement, via programming.

The purpose of the robot label applicator system is to increase the efficiency in production sites, where the RFID label position can change, depending on product or other reasons. New label positions should be programmed easily with a human-machine interface. During the production, the applying position can be switched instantly with simple software commands. Another great benefit of the proposed solution is that most of the components are commonly used products off-the-shelf. This minimizes production losses in case of broken components as they can be replaced easily with spare parts in stock.

In the project, an industrial robot, including a controller and human-machine interface was used for doing the movements and controlling inputs and outputs. For picking up the RFID labels a customized vacuum tool, mounted on the robot, was used. The robot application, which primarily contains target points, tool positions and moving functions, uses the RAPID programming language. It also handles the transmission control protocol (TCP) communication in a separate thread.

The applicator system first gets a command to print an RFID label, followed by the picking up command for the robot. The robot moves to the printer and picks up the label using the vacuum tool. With clearance from the production line control, the robot will apply the RFID label on the product on the production line. During the process, feedback and status messages are sent to the production line control system.

A functional label applicator system was implemented and assembled in this final year project. A long-term field test, under production environment, will follow soon. During and after the field test further enhancements in the system can be done, primarily in the vacuum tool and speed of the robot.

Keywords	RFID, label applicator, industrial robot

Contents

Abbreviations

ABB	Asea Brown Boveri (company name)
CRC	Cyclic Redundancy Check
EPC	Electronic Product Code
ERP	Effective radiated power
ETSI	European Telecommunications Standards Institute
GPIO	General-purpose input/output
GUI	Graphical user interface
HF	High frequency
IC	Integrated circuit
ID	Identity/Identification
ISO	International Organization for Standardization
IT	Information technology
LF	Low frequency
NFC	Near-field communication
PC	Personal computer
RFID	Radio-frequency identification
RTLS	Real-time locating systems
SAP	Systems, Applications & Products in Data Processing (company name)
SGTIN	Serialized global trade identification
TCP	Transmission control protocol
TID	Transponder identification
UHF	Ultra-high frequency
UPC	Universal Product Code

1 Introduction

Manufacturers nowadays are more often than before required to establish real-time tracking of their goods. The goods, for example, can be transported from a production mill to warehouses, from warehouses to ports and then to end customers. Real-time tracking enables the manufacturer and involved parties to see live data for location and status of each production unit, as well as live information of the company's stock. With ultra-high frequency radio frequency identification (UHF RFID) tracking solutions, the process of real-time tracking can be optimized and automated. RFID is able to identify items, when shipped or received – this feature can reduce errors from picking up wrong items. It can be used to store positions in detail, for example a warehouse area or other information. With RFID gates and RFID modified forklifts, almost no human action is necessarily required for using tracking. The accuracy and reliability of a well-planned RFID system increases the quality of work and information quality [1].

This thesis deals with the development and implementation of an industrial robot solution for applying RFID labels on goods. Finding a solution is aggravated by the manufacturers' requirement that the RFID label applying position must be alterable by command from the production line control, without manual action or rearrangement of the applicator. Conventional RFID applicators are very restricted with adjusting the label apply position. For major changes, conventional applicators need to be rearranged, which can mean huge effort, requirement of mechanical staff and production loss.

2 Radio-frequency Identification

2.1 Tracking Systems in the Industry

Full traceability of manufactured products has become a consistent demand caused by customers, governments and civil society organizations. Advantages are real-time tracking, accurate operational data monitoring and visibility of supply chain processes, such as warehousing, deliveries and consumption. Companies are making product tracing a more and more standard business practice throughout the supply chain for better transparency [2]. It can also help reduce process errors and rework. Quality and product safety certificates can require full traceability of products. An RFID system using company also improves the service for the customer, with a better work quality and delivery accuracy. An overview of the benefits in the supply chain can be found in figure 1.

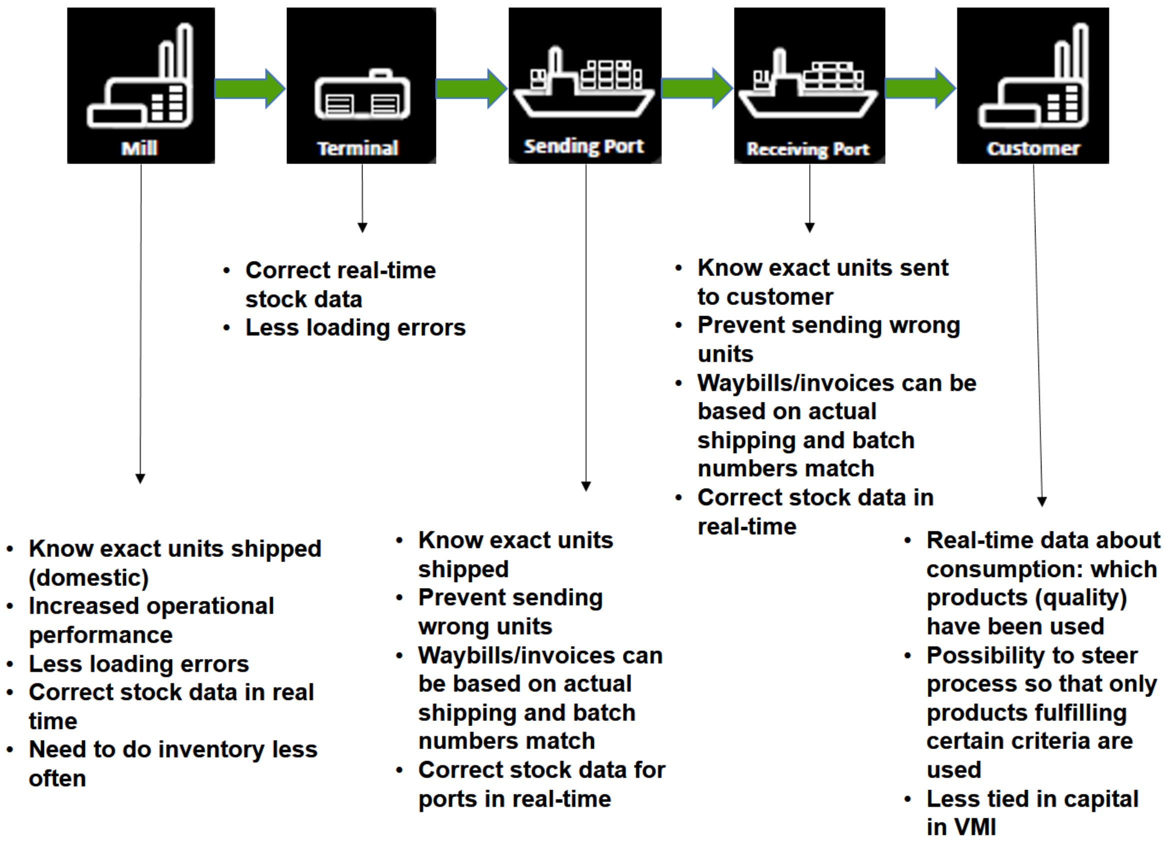

Figure 1: Supply chain and advantages with RFID tracking [2]

2.2 RFID Systems

RFID technology is using radio waves to identify and track transponders, also just called tags. Components of an RFID system are basically readers, antennas, tags and a host system. Data is transmitted over a modulated radio frequency from and to the tags. The following chapters will describe technology and components briefly.

2.3 RFID Technology

RFID uses license-free frequencies in different bands:

- Low frequency (LF) band RFID mainly operates within 100 KHz to 500 KHz. It has a short read-range of 10 cm and a slower speed than with higher frequencies. One of the main advantages of this frequency band is that it is less sensitive to radio wave interferences. Its main applications are for example access control, vehicle key-locks and livestock tracking.
- High frequency (HF) band RFID mostly operates at 13.56 MHz and provides read ranges between 10 cm and 100 cm. This system has a moderate sensitivity to interference and better data speed than LF RFID. It is used for Near Field Communication (NFC), smart cards and proximity cards.
- Ultra-high frequency (UHF) RFID systems mostly comply with the worldwide EPCglobal UHF Class 1 Generation 2 (ISO 18000-6C) standard and is specialized for item tagging. In Europe, the frequency ranges from 865 MHz to 868 MHz (ETSI regulatory standard), which enables a passive read range up to 12 meters. In other countries like in North America, it is between 902 MHz and 928 MHz. UHF RFID has the highest sensitivity to interference and low tag prices, between €0.05 to €0.15 [3].

Tags or labels for RFID are attached on the items to be tracked or identified. They basically have a microchip and an antenna, embedded in a plastic coating. The tags can be very thin and compact. RFID can have an active, passive or semi-passive configuration. The main difference lies in its tags.

Active tags use their own power to broadcast their information with the help of their internal power source, mostly in form of a small battery. The advantage of active tags is the great read range up to 100 meters and a continuous signal. A disadvantage is higher price, the size of the tag and that the battery has to be maintained. For active tags, there are also two different types: beacons and transponders.

Beacons are sending broadcasts every pre-set time interval. They are commonly used in real-time locating systems (RTLS), to continuously track the precise location of an object, whereas transponders only send their broadcast when they receive a radio signal from a reader [4].

In passive systems, the reader and reader antenna send radio signals to the tags. Passive RFID tags use the transmitted signal from the reader to power-up their chip and reflect a signal with their ID back to the reader. For that, passive tags do not need a power supply or transmitter, only a tag microchip and antenna. This configuration is cheaper, smaller and easier in production than the actives. If necessary the tags can be embedded, for example to resist high temperatures or chemicals. Also, a smart RFID label can be created by applying the passive tag between an adhesive layer and a printable paper label.

Semi-passive tags, also battery-assisted passive tags, use the internal power source to power the microchip on, and the energy received via the reader over radio frequency is used for backscattering. This configuration enhances the communication range and signal strength to the reader, in comparison to just passive tags [3].

Tag antennas are mostly designed to be very flat, which makes it perfect to embed them for example in a shipping label. They can be printed, etched, stamped with conductive ink, or even vapor deposited.
The purpose of the tag's antenna is to receive the reader's broadcast signal, power on the microchip with the wave's energy and reply to the reader. The amount of the collected energy depends on the size of the tag antenna's area; The larger the more energy will be harvested for the chip, which also increases the read range.
Tag antennas must be optimized, depending their applications. Tags can be adjusted for a particular frequency band and other tags might be specialized for good characteristics, when attached to certain materials, which may not work well for radio wave communication, for example metals, liquids or paper.

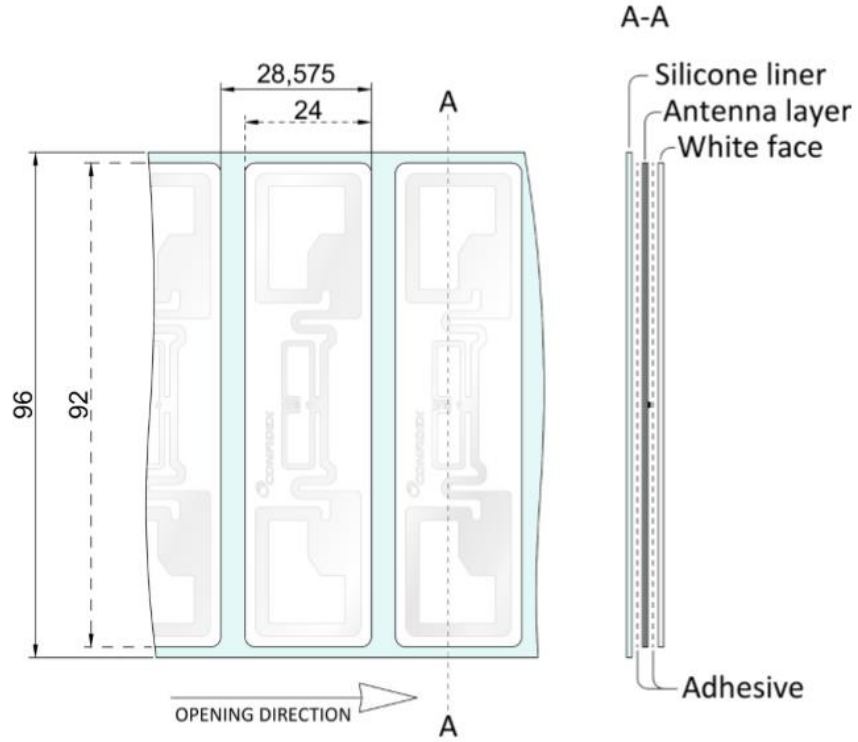

Figure 2: Confidex “Casey” RFID label structure [5]

Another requirement for RFID communication is the correct polarization of the tag’s and reader’s antenna. The RFID reader antenna transmits a wave that has both electrical and magnetic properties and is known as an electromagnetic wave. Most of the RFID readers are linear polarized antennas (i.e. dipole) propagating the electromagnetic wave entirely in one plane: vertical or horizontal, in the direction of the signal propagation. The best scenario for this wave propagation is when the tag orientation is known and fixed. The RFID tag antenna and RFID reader antenna should be matched in polarization to achieve the best read-rate. Tag readings can be more reliable with multiple antennas. Dual antennas can cover both polarizations, vertical and horizontal, so that a sufficient signal strength can be acquired in every alignment of the tag’s antenna to the reader’s antenna. Dual antenna tags require a different microchip.

2.4 RFID Reader

An RFID reader, also called interrogator, establishes the connection between the RFID tag and the client system software that is processing the information. The reader communicates with tags with amplitude or pulse-modulated waveform signals when they are in its read-range. In the final year project the reader displayed in the following figure was used.

Figure 3: RFID Reader Device - Impinj Speedway Revolution R420 [6]

Readers manage tag populations using three basic operations: select, inventory and access. Behind each operation there are one or more commands.
With the “Select” operation the interrogator can select a tag as inventory and access: Readers can use one or more select commands to select a certain tag population prior to inventory.
“Inventory” is the process to detect and identify tags in the interrogator’s reading range. An inventory round is created by transmitting a query command in one of four communication sessions. If one or more tags reply, the interrogator requests from each the electronic product code (EPC) and also other data, like the Cyclical Redundancy Check (CRC-16) code from the tag, and passes it to the client system for processing.
To access individual tags the interrogator uses the “Access” operation. It enables the readers to read, write or kill individual tags. An individual tag must be uniquely identified before it can be accessed [7] [8].

Readers can be installed in a stationary position or integrated into a mobile device like a portable, handheld scanner. Readers can also be integrated in electronic equipment or devices, and in vehicles, for example forklifts or gates.

To read tags RFID, readers and reader antennas are needed. Basically, reader antennas convert electrical current into electromagnetic waves and propagate them into space where they can be received by a tag antenna and converted back to electrical current. There are large options for reader antennas, the optimal antenna selection depends on the system's specific application and environment. Linear and circular polarized antennas are the most used antennas in RFID readers.

Linear polarized antennas have long signal ranges and high-power levels, which allows the radio signals to pass through various materials to access tags. The disadvantage is that linear antennas must be aligned with the tag orientation; otherwise the reader can have difficulties reading tags.

An alternative are antennas that radiate circular fields. This configuration is less sensitive to orientation, but cannot provide as much signal power as linear antennas. The choice of the right antenna depends on the required read-range between RFID reader and tags, as well as the possible orientations of the tags [4].

2.5 RFID Encoding and Printing (Gen 2)

New RFID tags usually come from the manufacturer without data or ID stored on the microchip. Some tags are already pre-programmed with sequential unique IDs, but do not always meet the format required by the end user. Tags are primarily used to identify specific assets, people or entities. For that, most RFID tags have to be encoded with specific data and identification. An encoder typically writes a 96-bit Electronic Product Code (EPC-96 Type 1) on the RFID tag and perhaps other data, like the barcode standard UPC (Universal Product Codes) [9]. The EPC is a universal identifier assigned to physical objects, unit loads, location or other items. It contains a manufacturer code, object type code and serial number of this single item. In the following figure, an EPC with the SGTIN-96 format is displayed, other formats are also possible [8].

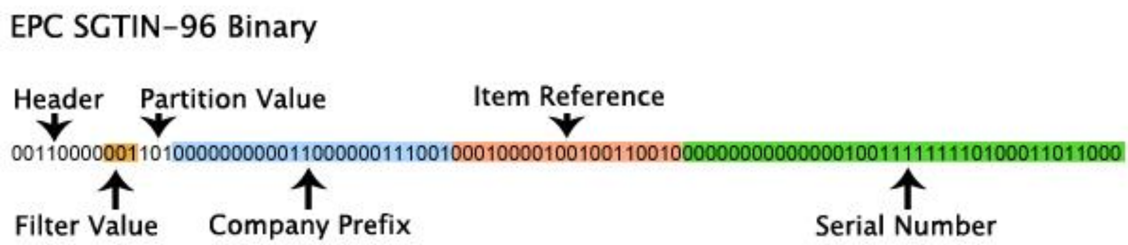

Figure 4: Electronic Product Code (EPC) SGTIN-96 structure [8]

To produce RFID smart labels, like for shipping, an ideal platform is an RFID smart label printer. An RFID printer has a roll of blank smart labels encapsulated and can setup a smart label on command. For that, the printer writes the data on an individually addressed tag and prints user defined information, like barcodes, addresses and more on the label [9]. The RFID label printer used in the final year project is displayed in the following figure.

Figure 5: RFID smart label printer - Zebra R110Xi4 [9]

2.6 Host Computer

RFID readers communicate with an RFID host computer through a computer network system. The host basically keeps track of all the tag data in its database and updates it as the data changes. The host can also forward all the tag information to another already existing customer system, for example SAP, and receive commands, like read tags. Other individual programs and tasks can also be implemented on the RFID host computer. In the next diagram the communication of an RFID system using a host computer is described.

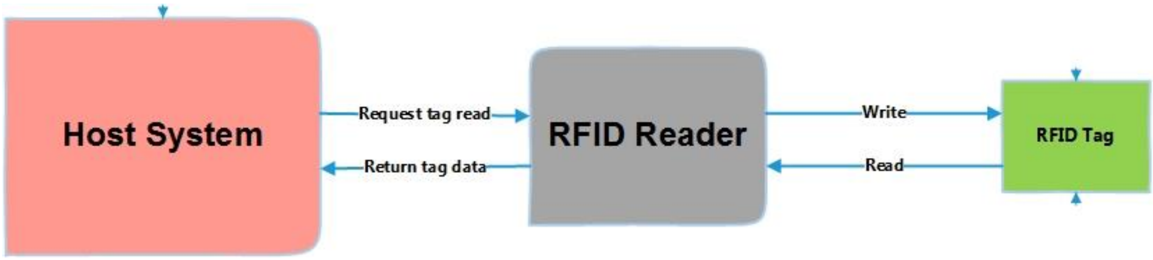

Figure 6: Communication of host system, RFID reader and tag

3 Industrial Robot

3.1 Introduction to Industrial Robots

Industrial robots can perform many tasks like picking and placing objects, similar to the movements of human arms. Likewise, tools can be mounted on the robot arm, for example a welding tool or RFID label pick-up tool of the final year project. The job of the robot arm is to maneuver the tool along a predefined path to execute a certain function of the work object, like picking up RFID labels. The advantages of industrial robots are in productivity, thanks to higher speed, accuracy, multitasking and reliability in comparison to human work. Robots can do dangerous tasks, for example in hazardous conditions and they can also lift heavy loads easily. Due to their accuracy, wasting too many resources can be prevented. The advantages lead to economic benefits for the company with quick return on investment [10].

Industrial robots principally consist of robot manipulators, controllers and a power supply. Robot manipulators are built with a combination of rigid links and joint combinations. Links are parts which connect axes and/or joints. Axes are components which allow the robot manipulator to move and cause relative motion between the adjoining links. Robot manipulators can be differentiated between wrist, arm and body, each with different kinetic functions. The arm and body are used to move and place tools or objects in reach of the robot. Usually the arm and body are constructed with three joints connected by the link parts. The function of the wrist is to orientate an object or tool at the workspace. Wrists include two or three smaller joints [11].

3.2 ABB IRB 1200 Industrial Robot

In the final year project, the modern ABB IRB 1200-5/0.9 industrial robot was used. The workspace for the robot is supposed to be very limited, so that a compact robot with a sufficient arm-reach was required. The availability of air ducts and signal features were also very important criteria for it. The robot has a payload of 5 kilogram, 900 millimeter arm-reach and a weight of 54 kilogram. Movements can be done with six different axes.

Figure 7: ABB IRB1200 [12]

Useful extra features of this robot product are integrated signal and power supply, 10 user defined signals on wrist plus one 100/10 Base-TX Ethernet port, four integrated air ducts for tools. Two controllers are compatible with this robot: IRC5 compact and IRC5 single cabinet [12].

3.3 Robot Controller

A robot controller is the logic unit of a robot system. Robot controllers are responsible for their moves and actions. The controllers are a combination of hardware and software to program and control one or more robots. The primary task of the controller is to control each actuator of the robot, for example the robot's servomotors. It can check and set general purpose inputs and outputs (GPIOs) and other robot integrated sensors. The controller also contains the user-defined application programming and enables communication with other computers or systems, for example over ProfiNET bus system, Ethernet or serial connection. The ABB controller's operating system is RobotWare [13]. In the robot applicator project, the ABB IRC 5C Compact controller is used, as displayed in the next figure.

Figure 8: ABB IRC5C Compact controller [13]

3.4 ABB FlexPendant

The ABB FlexPendant is used as a human-machine interface on the production site (also called TPU or teach pendant unit). The FlexPendant is a hand-held operator unit used to perform many of the tasks involved when operating a robot system: running programs, jogging the manipulator, modifying robot programs and more. With the FlexPendant the robot can be controlled in manual mode and also switched back to automatic mode. The FlexPendant is designed for heavy duty and factory environment – it resists water, oil and accidental welding splashes [14]. In this project, it enables the user to simply program new tag applying positions and change different other robot configurations, if necessary.

Figure 9: ABB Teach Pendant Unit / FlexPendant [14]

3.5 ABB Robot Studio Programming Environment

The robot manufacturer ABB offers its own programming software for implementing ABB robots, called ABB Robot Studio. The programming can be done on a PC offline or online, which means that the robot must not be connected to the PC during code writing. Also, the pre-tests can be done in the programming environment, thanks to the robot simulator. The simulated virtual controller is based on the real controller and allows performing realistic simulations [15]. The programming environment enables the user to program the robot with the help of a graphical user interface as well as text-based (RAPID). Room coordinates can be picked up easily and modified over the GUI, with a keyboard and mouse. With the GUI it is possible to implement the basic robot movements. For special functions, like Socket communication, text-based programming is necessary. The program of the GUI is synchronized in the text-based programming file. The text-based programming language is called RAPID and is specialized on robot applications [17].

ABB Robot Studio is primarily used during the installation of the system. For the end user of the system programming skills are not necessarily required, as every user modification can be done with the ABB FlexPendant.

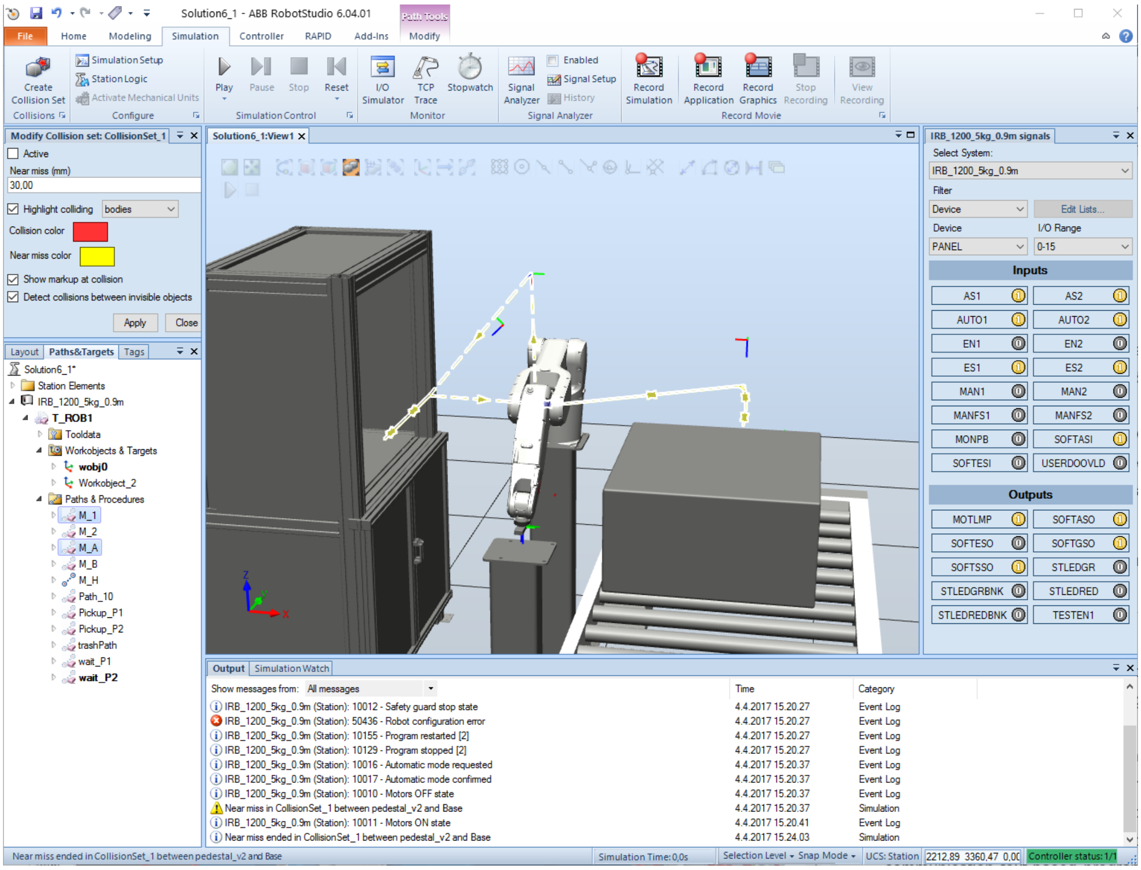

Figure 10: ABB RobotStudio simulation

4 Project Specification

4.1 Overview

An RFID tracking solution will be established for a manufacturer to enable real time tracking of their goods in their mills, warehouses, sending and receiving ports. The general requirement for this system is to obtain live data of their product's location and status, identifying goods and having live information of the stock. The data will be accessible for the manufacturer on their own IT platform. To register goods with RFID labels, for example for transport or relocating, the goods need to be scanned by an RFID reader and an action needs to be specified by the operator, like picking up or release. For that, forklifts equipped with an RFID reader, antennas and panel PC are used. As a backup, handheld RFID readers can be used. Handheld and panel computers are equipped with the client software to forward the data to the system.

RFID labels will be printed and applied on the product at the end of the production line. Tag positions can vary, depending on the product type or other reasons, so that a conventional RFID label applicator cannot be used for this purpose. A solution using an industrial robot will be used for that. The robot applicator system has a data connection to the production line control and executes tag printing and tag applying commands. Two redundant operating, standalone RFID printers are installed to print the labels. The labels will come out of the printer, automatically peeled off from the back paper. After the print is executed, the industrial robot will receive the command to pick up the label from one of the two printers. It will be picked up using a vacuum tool, modified for RFID tags. When the command is sent for applying the label on a certain position, the robot moves to it and presses the RFID label on an object. Before leaving the apply area the vacuum for the tool will be switched off and the blow-off function turned on, to prevent the label sticking on the tool, because of static charges. The robot will then turn back to its home position. The product with the RFID label will continue moving on the conveyor belt, passing an RFID reader, where the function of the tag can be checked.

The main components of the robot RFID tag applicator are the ABB IRB-1200 industrial robot combined with the ABB IRC5C Compact controller. Secondary components of the system are two industrial RFID smart label printers, Zebra R110Xi4s, and the client application, provided by Vilant Systems.

This thesis concentrates on a solution for applying labels on a product with flexible positions, using an industrial robot. Other components of the whole RFID solution will be described briefly.

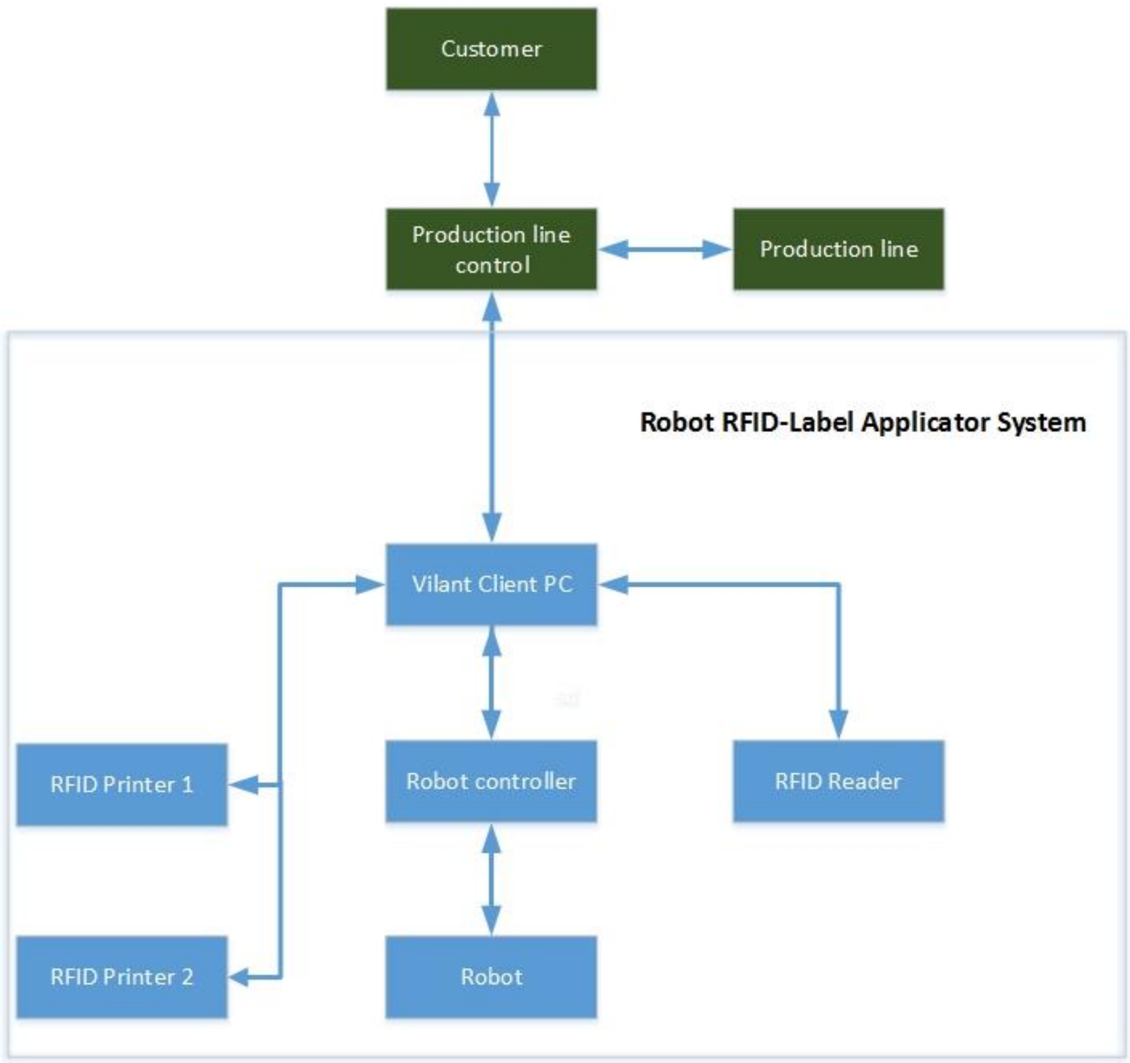

Figure 11: Overview of RFID solution

4.2 Tag Position

In the RFID system solution, the labels must be applied on a certain position to protect the labels from the harsh environment and still be readable by the readers. The protected label position depends on the product type – these tag positions have been tested beforehand and guarantee reliable reading and a good tag durability. It also has to be considered that the products vary in their height for some centimeters. For that, the robot program needs to be flexible with the height.

4.3 Tag Specification

For the final year project, passive EPCGlobal Class1 Gen2 ISO 18000-6C standard compliant tags with 128-bit EPC memory were used. The antennas of the tags are purposefully tuned for the specific material, where it is applied on. The requirement for the read-range through the customer product is 50 centimeters. The RFID label from Confidex, model “Casey” is used for this project. The summarized properties, according to the manufacturer’s datasheet, are listed below:

- Air interface protocol: EPCGlobal Class1 Gen2 ISO 18000-6C
- Operational frequency: Global 860-960 MHz
- IC type: NXP UCODE G2iL
- Memory configuration: EPC 128 bit; TID 64 bit
- Read range (2W ERP)*: on plastic up to 8.5 m, on cardboard up to 6.5 m (* calculated, theoretical values under optimum circumstances and maximum allowed operating power according to ETSI EN 302 208 (2W ERP)
- Face layer printable
- Adhesive background
- Weight: 0.6 g
- Tag dimensions: (92 x 24 x 0.2) mm
  [5.]

The tags data content will be according to GS1 SGTIN-96 Header, which basically includes the following information [5]:

- Company identifier (manufacturer of the tagged material)
- Factory ID

- Material code
- Year of production
- Batch number: five digits (00000 – 99999)
- Unit serial number (A running serial number generated by production system)
- A variable identifier

[8.]

5 Implementation

5.1 Pneumatic System

A very important component of this thesis project is the pneumatic system. It is required for picking up the RFID labels from the printers and stick them on the product bale. For picking up the label and moving it towards the conveyor, vacuum is used. The robotic arm will then press the attached RFID label on the bale. In some cases, the label sticks on the label pick-up tool of the robotic arm. For that reason, a blow-off function is additionally implemented. Vacuum and blow-off are both controlled electrically with pneumatic valves over the robot GPIOs. To produce suction at the label pick-up, a so called pneumatic non-contact gripper is used. It works with the principle of the Bernoulli grip [18], visualized in the following figure.

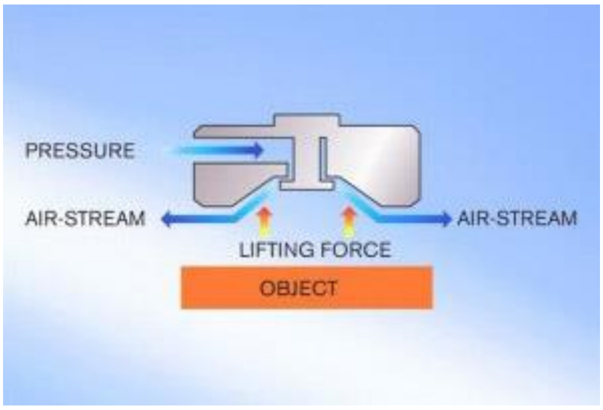

Figure 12: Bernoulli grip [16]

Different constructions of label pick-ups were tested in the final year project. One of the alternatives was a vacuum ejector with integrated blow-off or release valve, which can be mounted decentral. During the suction test the conclusion was made that it works well in the first test setup, which was without the robot. In the second test, where the robots' internal air ducts were used for operating the label pick-up, the result was too much loss of pressure through the robot. For that reason, the decentral solution was excluded. The final solution with the Bernoulli grippers is mounted on the label pick-up and requires only pressured air to operate. With that, the robot can be connected directly to the air supply with 5 bar pressure to compensate the losses, caused by too small a diameter of the air ducts. The four robot air ducts only have an inner diameter of 2 millimeters.

5.2 Robot GPIO Circuits

For controlling the pneumatic valves, status traffic light, external buttons and safety functions, these peripheral components must be wired correctly to the ABB IRC5 Compact controller. Safety circuits can be connected to certain connectors for using safety door switches, kill switches and more. In this thesis, the correct connection of the 2-polar safety door switch is described in “Electric Circuit Plan – Safety Circuits”, as seen in the next figure.

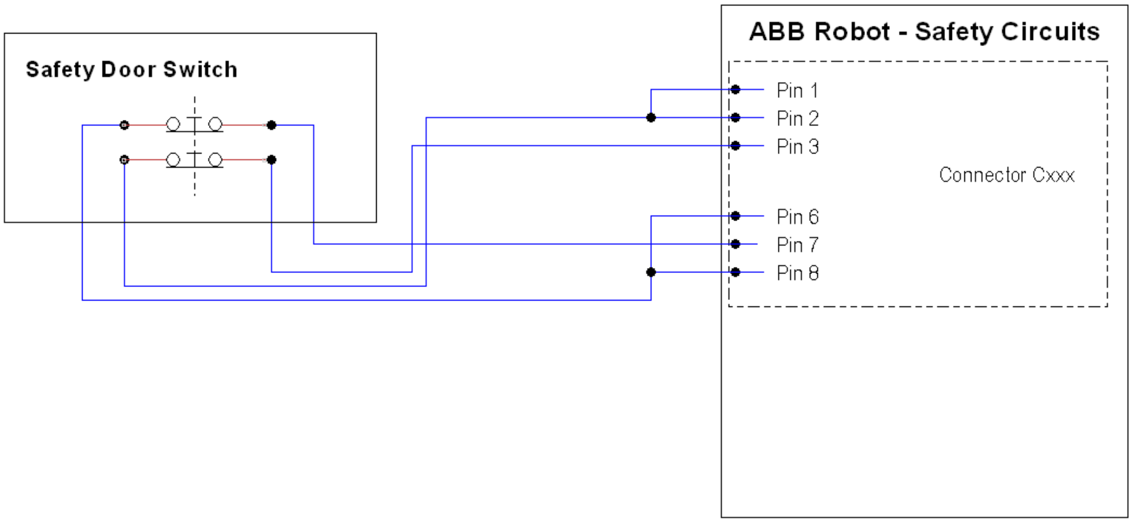

Figure 13: Electric Circuit Plan – Safety Circuits

For connecting the peripheral devices to the GPIO connectors, they have to be configured in the robot program and then connected to the pins on the connector, according to the configuration. Each connector also needs a reference voltage. The following figure shows the connector plan for the GPIOs. Full “Electric Circuit Plan – Applicator GPIOs” can be found in the appendix.

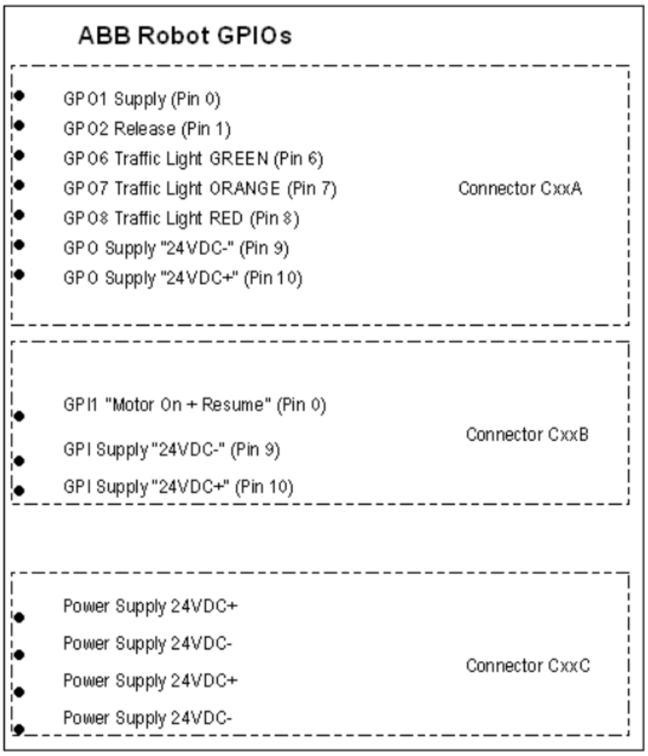

Figure 14: Connector Plan - Applicator GPIOs

5.3 Robot Programming

The robot controller application is responsible for establishing the TCP socket communication with the client program, executing the moving path and controlling of the integrated GPIOs. The implementation of the robot software is solved in two parallel running tasks, programmed in RAPID: a main task and a background task.

5.3.1 Main Task

The main task basically controls the movements and GPIOs. The main task is inactive while there is no command; it is waiting for commands from the background task. The main task includes all the tool coordinates and orientations for each target, as well as, how each command will be performed, like the path and GPIO controls. It also has specified what feedback messages to return, depending on the move command. The activity diagram below shows the simplified process of the main task.

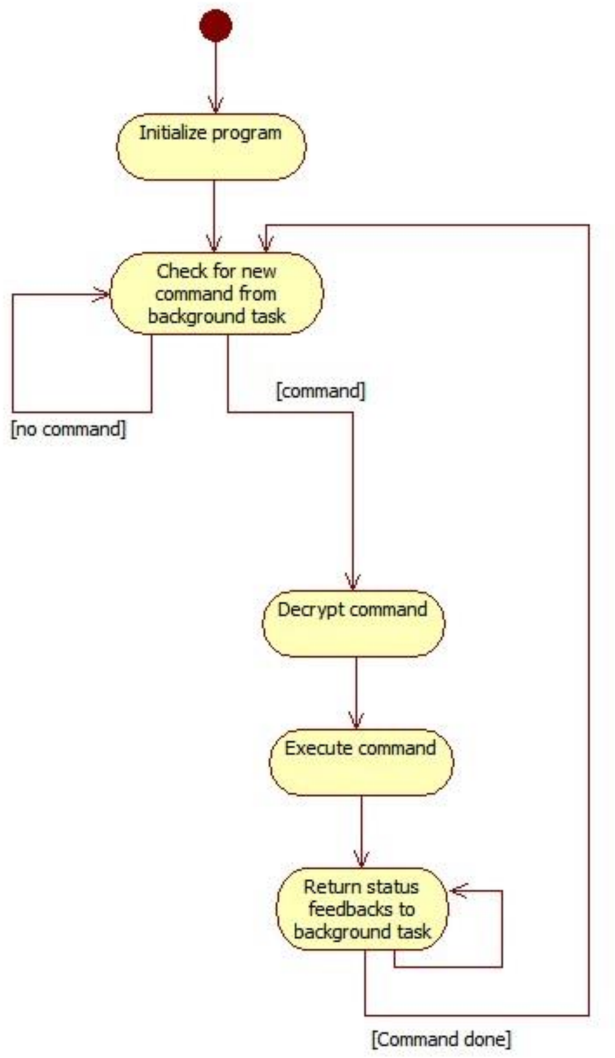

Figure 15: Activity diagram - main task

The main task has the following moving functions implemented: “Move to Printer 1”, “Move to Printer 2” for going to one of the two RFID printers and then pick-up the label”. “Apply tag on A” or “Apply tag on B” presses and releases the picked-up label on the product position A or B. “Move to home” brings the robot-arm in its home position. “Dispose label” disposes the label at a particular place, in case an error appeared.

In the apply-move implementations minor deviations in the product heights have to be considered. For that reason, the contact pressure needs to be monitored and reduced, while touching the surface of an item, to prevent damages. To press a label with light pressure on the product, the collision detection of the robot needs to be decreased in its sensitivity. In the robot implementation, the software option “SoftMove” is used for that purpose. The SoftMove is configured to press the RFID label with light pressure on the product. When a certain resistance is reached, the robot stops the pressing move [20].

5.3.2 Background Task

The background task handles the TCP socket communication with the client software and forwards valid commands to the main task. The background task also includes an error handler for the TCP socket communication and returns status feedback to the client program. It is mandatory for the robot software to send the following feedback messages to the client program: Acknowledge command, “Move executed” and errors. The following activity diagram describes the general process of the background task.

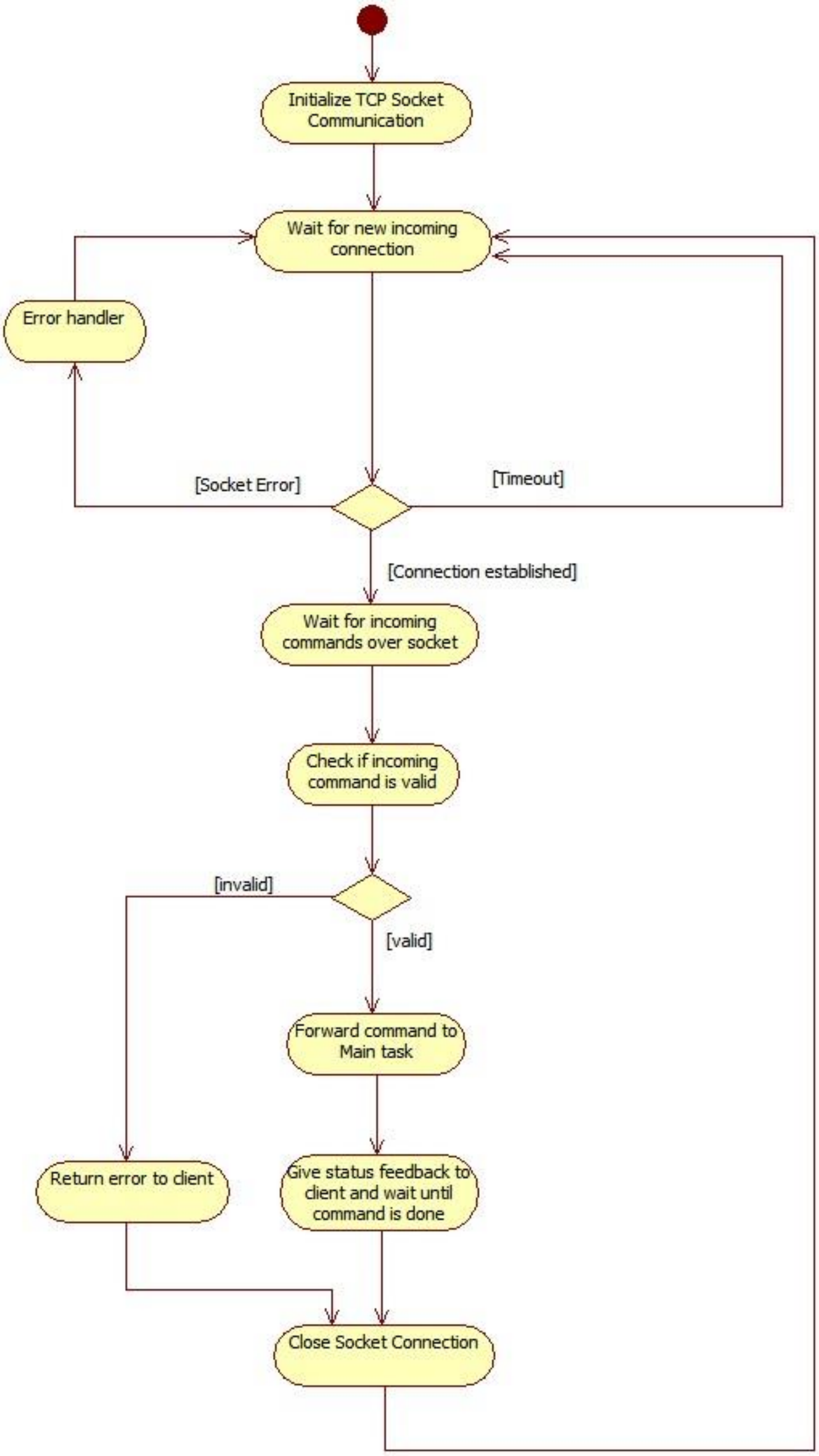

Figure 16: Activity diagram - background task

6 Testing

Tests were done during the implementation phase, in addition to the final tests. The system functions to test were the label pick-up, robot actions, TCP socket communication and process.

The first tests were about the label pick-up: Different concepts of label pick-ups were tested in a laboratory. The test setup was the pneumatic cabinet, including the valves, supplied with pressured air. The valves were controlled with a manual electric switch. With the tests, the design of the label pick-up and the approach angle was determined.

The subsequent tests were about the TCP Socket Communication between the robot and the client program which is installed on an industrial panel PC. Commands were sent from the production line control over the TCP socket to the robot and the action was displayed on the robot simulation of the ABB Robot Studio. The test was about to verify that the communication was working, the commands were executed correctly and the right feedback messages were returned to the client.

As soon as the robot was delivered, the tests started with the actual robot. In the test setup the robot and all other components, like Client PC and pneumatics, were built up provisionally. At the beginning the robot program was running with reduced speed and without printers in its range, to see how the real setup differs from the simulation. After that, the new printer and label apply target points were entered using the ABB Flex-Pendant. The “printer-approach moves” and “picking up the label” are the most critical maneuvers of the robot; they were tested extensively. Final tests were made with sending a pick-up and apply command over the Panel-PC, like under normal circumstances. Under special focus was also the SoftMove function, which is used to compensate height deviations of the products and to press on a label with light pressure. To test that function, empty cardboard boxes with different heights were used as items to apply the tag on. Without the SoftMove function the boxes were not even touched, because the box surface was below the programmed apply position.

Figure 17: Robot test setup

7 Conclusion

The final year project's aim was to create a system for printing and applying labels on products using an industrial robot. The system is meant to be used in a production environment and to be installed as part of the production line. The main benefit of the robot system is its high flexibility; all position coordinates and movements, like pick-up and apply tag position, can be modified easily using the human-machine interface. The second great advantage is that the technical components can be set up or exchanged easily; the used devices are standalone and off-the-shelf products with a high availability, only the individual program or configuration needs to be uploaded manually.

The practicability of the concept using an industrial robot for RFID tag application has been demonstrated during the tests. The system receives a print and apply command from the production line control over the client computer, which then forwards an "RFID print label" command to one of the RFID printers. The client program always chooses a printer, which is operational and of course available. After printing the industrial robot moves to the printer, where it picks up the RFID label using the vacuum tool. With clearance from the production line control, the robot-arm moves towards the conveyor to apply the label on the product. The robot presses the label with slight pressure on the product and releases it using pressured air. Then the applicator arm moves back to its home position and gives feedback to the client. The RFID reader at the conveyor belt will check the correct function of the RFID tags.

The robot movement precision enables the system to pick-up and apply tags with a high accuracy. The ABB FlexPendant allows modifying coordinates via a joystick within 10 minutes, which saves a lot of time and resources in comparison to changing the position of conventional RFID applicators. Many different positions for print and application can be programmed and stored, without any mechanical modifications, as long it is in operation range of the robot-arm. With different commands from the client software, the robot can switch flexibly between the different positions for print or apply.

Field tests were not carried out in the study. A final version of the RFID label pick-up tool can be considered, after the results of field tests in the mill production line. During the field tests, careful modifications in the moving paths and other configurations of the industrial robot can be done to improve the RFID applicator's function. For example, the speed, approach paths, label pick-up and applying procedures can be optimized.

To keep the robot RFID applicator as simple as possible in this stage of development, several optional technical features were skipped. For instance, sensors for detecting labels on the tool or verifying the correct operating position for the printer on the printer table can be implemented in further development steps to improve the function of the applicator. The robot software implementation can be enhanced with more error handlers during pick-up and when applying actions.

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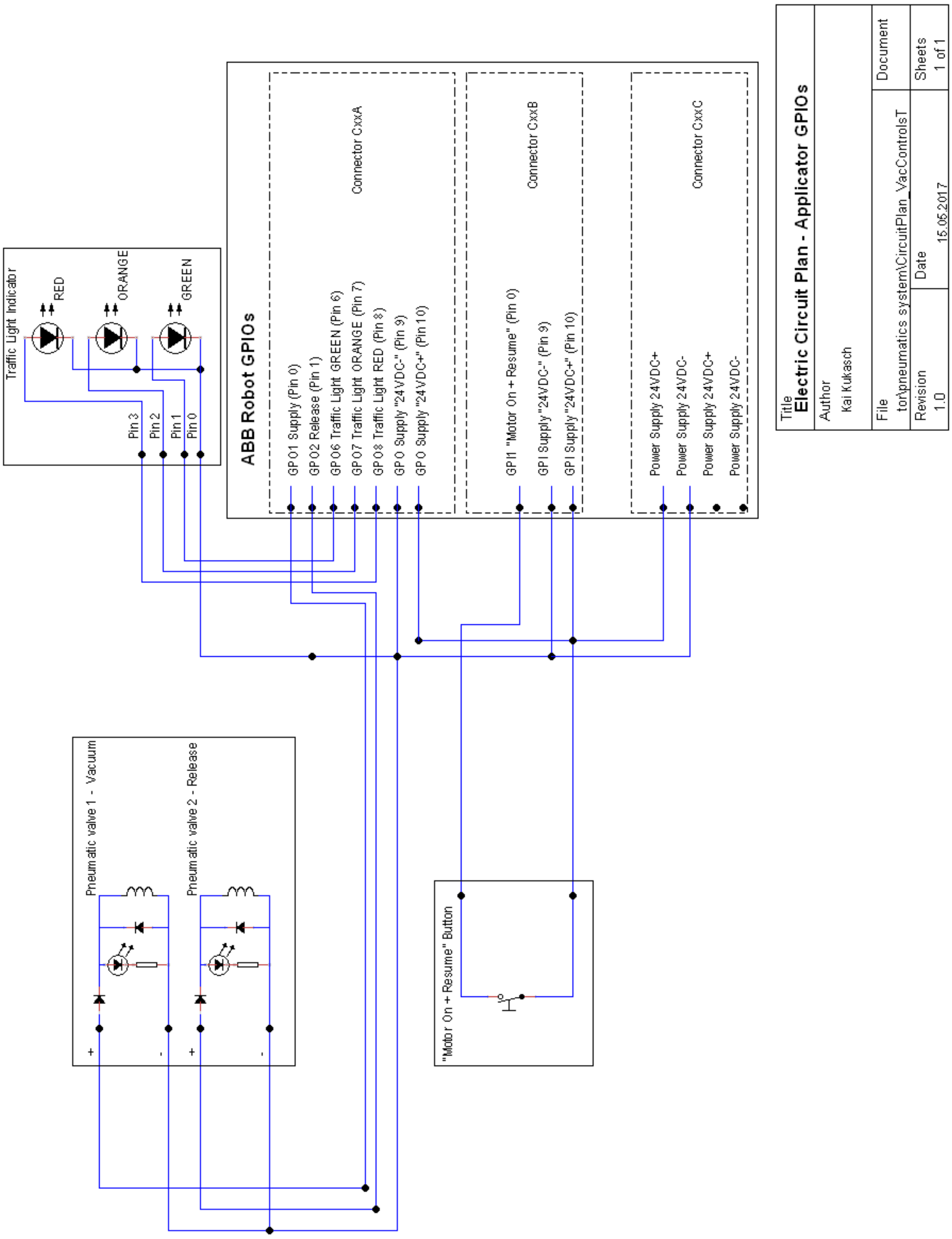
Appendix 1


Title
Electric Circuit Plan - Applicator GPIOs
Author
Kai Kukasch
File
to\pneumatics system\CircuitPlan_VacControlsT
Document
Revision
1.0
Date
15.05.2017
Sheets
1 of 1
ABB Robot GPIOs
Connector CxxA
GPO1 Supply (Pin 0)
GPO2 Release (Pin 1)
GPO6 Traffic Light GREEN (Pin 6)
GPO7 Traffic Light ORANGE (Pin 7)
GPO8 Traffic Light RED (Pin 8)
GPO Supply "24VDC-" (Pin 9)
GPO Supply "24VDC+" (Pin 10)
Connector CxxB
GPI1 "Motor On + Resume" (Pin 0)
GPI Supply "24VDC-" (Pin 9)
GPI Supply "24VDC+" (Pin 10)
Connector CxxC
Power Supply 24VDC+
Power Supply 24VDC-
Power Supply 24VDC+
Power Supply 24VDC-
Traffic Light Indicator
RED
ORANGE
GREEN
Pin 3
Pin 2
Pin 1
Pin 0
Pneumatic valve 1 - Vacuum
Pneumatic valve 2 - Release
"Motor On + Resume" Button