



Improved flexibility for safety-related equipment in robotic cells



1 Introduction

System 3R, located in Stockholm, Sweden, is part of the GF group and the world's leading supplier of clamping, palletizing and automation systems for machine tools. A typical production unit is called a cell, and consists of an automated stock managed by a robot which can utilize up to 12 machine tools.

In the most current project the motion control unit, the drives, and the motors of the automation cells are to be replaced with a solution from Beckhoff. In combination the programming tool TwinCAT3 from Beckhoff is introduced in System 3R.

Within the Beckhoff solution the safety programmable logic controller (PLC) will change as well. Combined with the new programming environment the whole safety solution will be adjusted. One part of this solution is the installation of the standard safety projects on the customer site, by a service engineer. However, it is not allowed to change the safety project on site by programming through the service engineer.

During the bachelor thesis, different ways to create safety projects within TwinCAT3 were evaluated. In addition a human machine interface (HMI) was created and as a next step, based on an evaluation, a test program was created for test purposes.

The test program included features as:

- The possibility to create a TwinCAT3 safety project
- Different safety projects to choose from
- External configuration
- Error free TwinCAT3 execution

The system Engineering was used as the primary method during the whole project in combination with the Crystal Clear method during the programming parts.

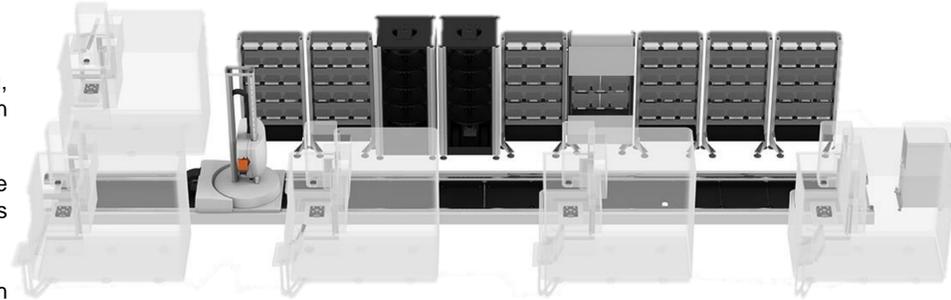


Figure 1: Example of an automation cell by System3R [1]

2 Hardware and software

During the bachelor thesis, the hardware acquired during internship III from Beckhoff was used. Consisting of:

- 1x Industrial PC (IPC)
- 1x 24V power supply
- 1x Drive Power Supply
- 2x Motor drives
- 3x Motors
- 1x Safety PLC (yellow slice)
- 1x Safety input slice (yellow)
- Multiple standard input/output (I/O) slices

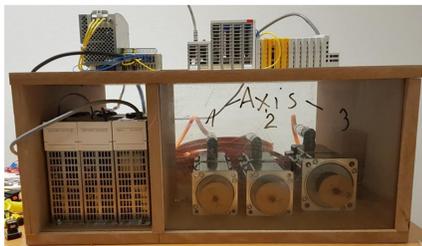


Figure 2: Test frame with the hardware solution from Beckhoff

The main software used was the TwinCAT3 from Beckhoff which is similar to Tia Portal. In addition, a new program to preconfigure the desired safety program had to be created. The programming was realized in C#.

TwinCAT3 is a powerful tool with limitations. It is not possible to create programs or project from outside the environment other than copy and/or customize the existing programs. The only option to communicate with TwinCAT from the outside is a specific program library, which therefore also was used.

3 Proof of concept

The current concept for the installation of the safety project at the customer site works as follows:

1. Install the standard PLC program on the IPC during the setup
2. Complete the hardware installation at the customer site
3. Connect the service computer to the IPC from Beckhoff
4. Start the configuration program and choose the hardware configuration installed in step 2
5. Confirm the configuration

During the bachelor thesis the proof of concept was realized by visualizing the configuration with the feedback lights on top of the standard I/O slices as shown in Figure 3. The lights switch on and off depending on the previously made configuration.



Figure 3: Proof of concept

4 Solution

The solution works as follows:
After the (1) service engineer connected his computer to the (6) IPC, he will activate the (2) configuration program and enter the hardware configuration. By confirming, the program will create a (3) .csv file according to the configurations. After the .csv file is created, (4) batch files will be activated. Those will execute (5) library commands to copy, download and activate the desired safety project, according to the .csv file, on to the (6) IPC. Through the connection to the IPC, a live view on the configuration via the HMI is possible.

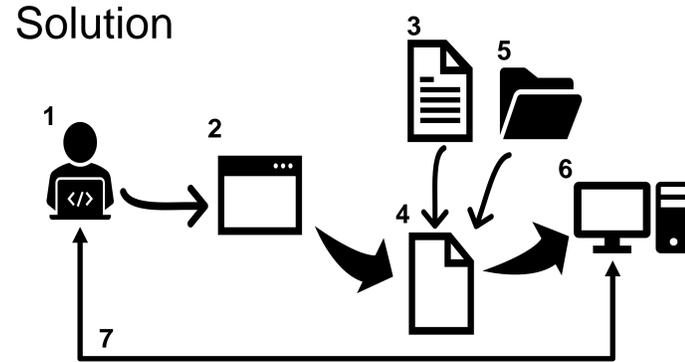


Figure 4: Allegory of the software solution

5 Further steps

The focus of the current concept is set on the direct communication between the EtherCAT master and the safety PLC. In a real environment, the installation will most likely not only contain an EtherCAT master but also multiple slaves. Each of the slaves as well as the master will get a standard set of safety and standard I/O slices. A further step would be to create a project including an EtherCAT master and an EtherCAT slave, both equipped with a safety PLC and standard I/O slices.

The goal would be to configure each safety PLC independently, to proof the flexibility of the concept under real conditions. In Figure 5, a possible setup with a master on the left side and a slave on the right side is shown.



Figure 5: Master and slave setup

Alternatively one could put the test program into service. The hardware shown in Figure 2 has been installed into a robotic unit, displayed in Figure 6. The goal would be to first run the motors in the cabinet and secondly, create a safety program including standard safety devices like an emergency stop. This would give a better overview on how much effort would be needed for projects, regarding individualization.

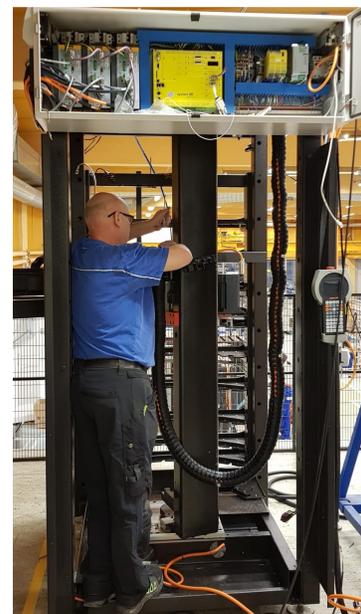


Figure 6: Mounting of the hardware solution

Sources

- [1] <https://www.gfms.com/content/dam/gfac/proddb/Transformer/automation-transformer-extend.jpg>