Graduate thesis

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of ICT and Natural Sciences

Daniel Erichsen
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Safety System for workers in freezer room

Bachelor Thesis for Optimar AS

Graduate thesis in Automatiseringsteknikk
Supervisor: Kjell Inge Tomren, Ottar Osen
May 2020

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Daniel Erichsen, Eilev Brustugun, Shajeevan Panchardcharam

A thesis presented for the degree of Bachelor in Automation IE303612

Faculty of Information Technology and Electrical Engineering
Norwegian University of Science and Technology
Norway

09.01.20 - 20.05.20

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Preface

Health, safety and environment is a concept that includes most peoples involvement in today's working life. Optimar in Aalesund seeks to optimize the safety of all workers using their fish handling equipment.

During a fatal accident at the trawler Geir II, Optimar discovered the lack of accessibility to contact critical personnel.

One area where the environment is harsh and safety is lacking, is inside freezer rooms. This thesis elaborates the development of a safety system for workers inside freezer rooms, with the intention to minimize the outcome of injuries happening inside these freezers.

The bachelor thesis is a result of a collaboration between students at NTNU Aalesund and the fish handling company Optimar AS.

The project is a part of the bachelor program in electrical engineering, with specialization in automation, at the Faculty of Information Technology and Electronics. The report is written and prepared by a group of students with different backgrounds. Two students with a certificate of apprenticeship, one in automation and one in data electronics, the last member having a theoretical background from high school.

We inform the reader of this thesis, that the report is written with the intention that the reader has the general understanding of the subjects engineering and automation.

Acknowledgment

We would like to thank our supervisors, and all our contributors who have helped us during this project:

- Kjell Inge Tomren - Professor, NTNU
  For contributing very useful and essential information for the task, as well as valuable data for several of our analyzes.
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  For making the collaboration possible
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  For guidance throughout the project
- Richard Giske - Group Leader Programming, Optimar AS
  For advice's and tips for the programming of GUI
- Joakim Andersson - Project Manager, Tele-Radio
  For guidance arround communication for the handheld transmitter and receiver
- Thomas Sørheim Egge - Production Engineer, Tele-Radio
  For programming the handheld transmitter as desired

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Sted: Aalesund

Dato: 20.05.2020

Acronyms

PLC	Programmable logic controller
HMI	Human Machine Interface
IP	Internet protocol
LAN	Local area network
CCTV	Closed-circuit television
WLAN	Wireless local area network
PC	Personal Computer
GUI	Graphical User Interface
LED	Light Emitting Diode
IP-rating	International Protection
DI	Digital Input
DO	Digital Output
OS	Operating system
LD	Ladder Diagram
SFC	Sequential Function Charts
FBD	Function Block Diagram
ST	Structured Text
IL	Instruction List

Terminology

PLC — Logical controller used in the industry to control machinery, sensors and similar

PLC modules — Additional modules that can be added to PLC for more functionality:

- Power Supply Module: Module used to supply other modules with power, makes it possible to have different power supplies for different modules.
- I/O-Module: Module for PLC consisting of input and/or outputs. Could be either analog, digital or both.

EX-area — Explosion Hazardous Areas. The areas are divided into three zones for gas: Zone 0, Zone1 and Zone2, and three corresponding zones for dust: Zone 20, Zone 21 and Zone 22. Where zone 0 and 20 are high risk and 2 and 22 are low or non risk.

NPN and PNP output — NPN outputs a zero voltage signal. When an output gets triggered it will connect the output to the negative supply. PNP outputs a positive voltage signal. When an output gets triggered it will connect the output to the positive supply.[13]

Executive Summary

The intention of the thesis is to develop a field leading safety system for freezer rooms in fishing vessels. The system must be capable of being mounted in the new fishing vessel Geir III, and to the same extent retrofitted in existing fishing vessels. The safety system aims to minimize the outcome of accidents and be life saving, with a minimal effect to the work flow.

On the 30th September 2010 a fatal accident happened to one of the workers of the trawler, Geir II. Optimar was one of the core suppliers delivering equipment for fish handling to Geir II. During this accident Optimar discovered the lack of safety for workers working alone in the large freezer compartment of Geir II. Optimar is currently in the process of delivering equipment to a new version of Geir II, Geir III. One of the goals of this new vessel is to improve the safety of the workers.

The approach of the thesis is to build a prototype that would serve as a concept of the finalized product being implemented in Geir III. The aim of the prototype is to prove that such a safety system can become a commercial product for Optimar.

The result of the prototype left us confident that the safety system can be a commercial product for the fishing industry, and contribute to minimizing the severity of accidents. The prototype complies with the standards set by Optimar, and is designed with scalability and versatility in mind. Making it possible for the safety system to be implemented in new vessels or retrofitted in older vessels, without any major modifications.

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1 Introduction

1.1 Background

30th September 2010 the fishing vessel Geir II, located just outside of Tromsoe (Tromsø), experienced a fatal accident to one of it's workers. The casualty was the factory manager on board. [Geir II]

The ship was recently delivered from the shipyard, with DNV classification and initial inspection by the Norwegian Maritime Directorate. Much of the technology on board was already known and in use on the sister ship, but the area where the accident occurred was a pilot plant delivered by Optimar.

This is one of the more severe personal injuries that have happened on a Norwegian fishing vessel, but it's not the only personal injury that has occurred.

Optimar is in the process of delivering equipment to the new vessel, Geir III. Geir III will be an improved version of the previous vessel, Geir II. One of the goals of this new vessel is to improve the safety of the workers.

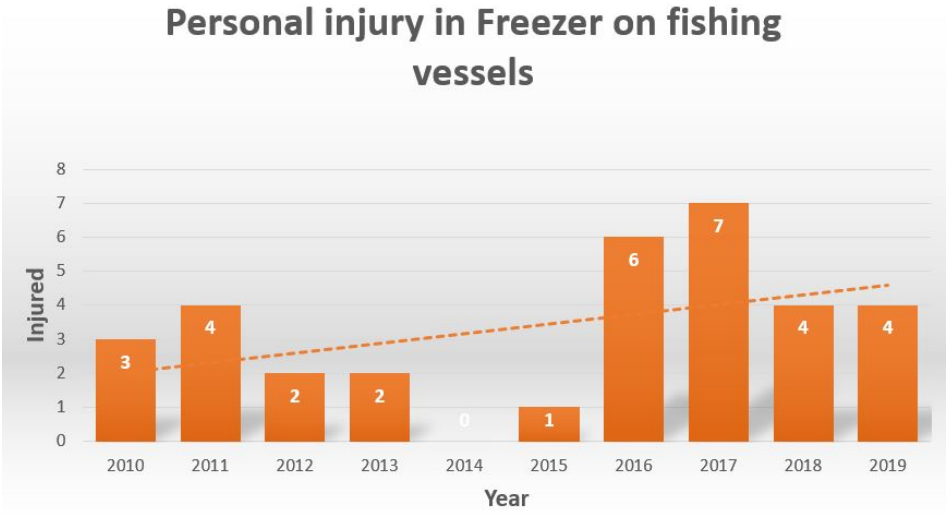


Figure 1: Personal injuries statistics

1.2 Project introduction

Optimar in Aalesund seeks to prove that an industrial safety system can minimize the outcome of accidents happening at fishing vessels. The most used safety system in freezer rooms today is camera surveillance. These camera surveillance systems are normally not manned, because of the economic aspects and time consumption.

A solution to this problem can be an accommodating safety system that meets the needs of safety and with minimal effect to the work flow. Nowadays personnel working in freezers has no ideal way of contacting other workers or bridge personnel if an accident occurs.

The large freezer compartments are normally located at the bottom deck and the accessibility to radio or other workers are often low to non existing. When an injury occurs time is of the essence. If a worker is crucially injured there should be a way of contacting bridge personnel and/or medical help. On the other hand if the worker is unconscious the system should automatically report an incident to bridge personnel.

In this paper, the focus is on simplicity in design, user-friendly / accommodating, and finally saving lives or minimizing injuries. During consideration of different choices, the priority will be in low cost and accommodating it's use.

1.3 Bachelor degree specification

The final semester of the bachelor degree, for automation students at NTNU Aalesund, conducts a major project often given by companies. The purpose of this project is to give the students an introduction to project management. In addition to creating an association to the theory that has been applied over the years, and to convert the knowledge of theories to practice.

The work of this project is set from mid January to mid May, and it's calculated that each member of the group gets 500 work hours. After the project are completed and handed in to the supervisor the final grade will be conducted.

1.4 Collaboration

Fish handling with care is the heart and everything for Optimar. Caring for both quality fish-handling and their customers needs has been a key factor in Optimar's 80-years long history. This philosophy has led Optimar to become a strong, competent and preferred supplier.

Optimar AS is one of the world's leading innovation companies in their field. The company offers technology in robotizing and automation and provides fish handling solutions and processing equipment adapted for vessels, land-based factories, and the fish farming industry.[21]

Figure 2: Collaboration Partners

1.5 Limitations

In the spring of 2020 a pandemic emerged, Covid-19, influencing the thesis. This giving the thesis several limitations that will be further explained in the next chapters.

The significant limitation of the thesis comes from the thesis itself. The bachelor project is a safety system, and safety systems should not be too complex. The importance of a safety system is it's reliability, and therefore the need for complex features that could eventually fail is not needed.

1.6 Aim and objectives

The purpose of the project is to design and develop a safety system that is industrial, and lifesaving. The group aims to design and develop a well-functioning safety system that is thoroughly documented and invites workers to turn around their routines. The system will be developed with the intention to be implemented in Geir III, to minimize the outcome of injuries. The main task will be to develop a system that is user friendly and meets the requirements set by Optimar AS.

The group members will also gain knowledge and project experience that is relevant to future work relations. Core objectives for creating this system is mentioned below:

- Design and develop a system that is suitable to operate in fishing vessels.
- Design a suitable GUI that is user friendly and invites workers to turn around their routines and use the new safety system.
- Suitable for the bridge personnel, maximum information in minimal view.
- Program the logic so that the workers aren't able to work around the system.
- Make a system that is scalable and versatile.
- Make the safety system redundant.
- Develop a system that can be implemented in Geir III.

1.7 Long term goals

- Minimize outcome of accidents
- Saving lives
- Develop a field leading safety system for freezer rooms in new vessels
- Develop a system that can be retrofitted in existing fishing vessels

1.8 Report Structure

This project report will describe the work and justify the choices made during the project period. Each chapter will have a brief introduction describing the content. The group starts by explaining the theory behind the techniques, technologies and materials used in the project, then how the group approaches the task. Furthermore, the group explains the results of the project and at the end the group will end up with a conclusion. The structure of the report is set up in an intuitive and simple way as shown below.

Chapter 2 - Theory Elaborates the theory behind the essentials used during the project. Programming languages, communication methods, systems, special equipment used and programs.

Chapter 3 - Approach This is a brief description of what is considered as the required specifications, as well as how to approach tasks and problems to develop the system. Method of planning, approach and adjustments are explained.

Chapter 4 - Materials Contains all the materials, components and information that is used to create the safety system.

Chapter 5 - Design Explains the design of both hardware and software.

Chapter 6 - Implementation Elaborates how the system is implemented, how components were installed.

Chapter 7 - Reviews Explains the testing of the system and how the prototype has been changed throughout the project, and how the problems that occurred were solved.

Chapter 8 - Results Presents the results, and how the systems performs.

Chapter 9 - Discussion Discusses the final result, students learning profit from the assignment. Also, some suggestions for further improvement of the prototype is mentioned.

Chapter 10 - Conclusion Summarizes the level of completion of the project and concludes the bachelor report.

2 Theoretical Basis and Background

In this chapter, the theory behind components and principles used are presented. Theory as presented underneath will be necessary for making decisions throughout the project.

2.1 Fishing vessels and fish handling

There are many different fishing vessels on the ocean today. Trawls, seiners and line vessels are some of them. A trawler is a fishing vessel that is designed to use trawl nets in order to catch a large volume of fish. Seiners uses surroundings and seine nets and line vessels uses one or more long heavy fishing lines. [43]

Figure 3: Fishing vessels [39] [38] [40]

All of these fishing vessels mentioned above have a freezer compartment where the fishes are stored. Once the fish has been cleaned and treated on the factory deck it has to be frozen in blocks of about 25-50kg before it is brought down to the freezer compartment.[43]

2.2 Geir III

Geir III is a fishing vessel manufactured by Skipsteknisk AS and is defined as a longliner. At a length of 61.80 meters and a width of 13.50 meters, Geir III ordered by HP Holmeset, will be one of the biggest and most modern vessels of it's kind in the world.

The vessel will be equipped with moonpool[M] and autoline equipment for approximately 70,000 hooks. Geir III will be able to produce both frozen HG[HG] and fillets, and has a loading capacity of 500 tonnes. The shipping company is now further developing the concept from its previous vessel Geir II, and improvements are being made such as moonpool, block hotel, factory and propulsion solution. [16]

Figure 4: Geir III [45]

2.3 Freezer room

In this modern days as technology evolves the refrigeration system temperature is between -30°C to -35°C. The walls and doors are four to six inches thick and are often made of galvanized steel, stainless steel or aluminum.

The freezer compartments of the various fishing vessels are u filled with 500 tonnes of fish and transport equipment such as a truck, so that it's possible to move around on pallets and stack. The size of the freezer compartment in the fishing vessels depends on the type of vessel, but it usually has a ceiling height of 4-6 meters. Camera surveillance is used in several of these freezer rooms, but there are also some fishing vessels that doesn't have this type of surveillance. Although some freezer rooms may be cctv monitored, these cameras aren't manned for surveillance, and may contain blind spots. [8]

2.3.1 Working inside a freezer

When you're inside a tightly sealed, extremely cold giant metal box you need to worry about hypothermia, frostbite and air supply. The normal core body temperature of a healthy person is between 36,5°C and 37,5°C . Hypothermia occurs when a person's core temperature drops significantly below normal. A person suffering from hypothermia will become tired and confused. There have been several instances where workers inside the freezer have been trapped, between pallets and lifts, which have caused workers to experience hypothermia and then perish. A list of injuries that occurred in freezer rooms from 2010 to 2020 is shown bellow. [27]

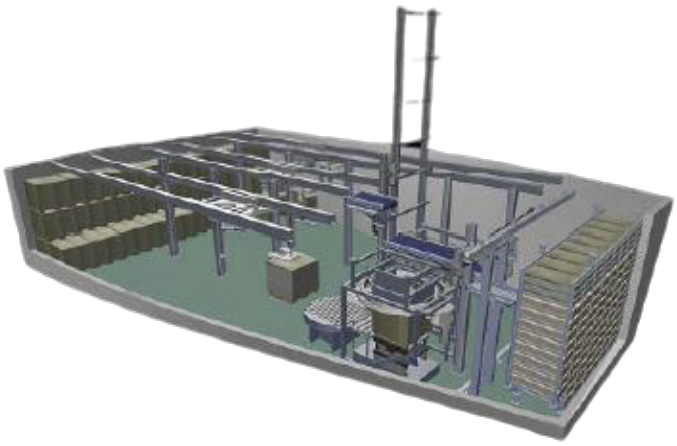


Figure 5: Freezer room [Geir II]

Injury statistics at freezer room on fishing vessels

Date of injury	Injury group	Work related to injury
27.02.2010	Shock / crush injury	Distribution of fish on board
14.06.2010	Shock / crush injury	Distribution of fish on board
06.07.2010	Shock / crush injury	Harvesting treatment
02.01.2011	Shock / crush injury	Distribution of fish on board
23.04.2011	Tripping injury injury	Distribution of fish on board
26.04.2011	Shock / crush injury	Loading / unloading
12.10.2011	Tripping injury	Unknown
06.10.2012	Tripping injury	Distribution of fish on board
10.11.2012	Shock / crush injury	Distribution of fish on board
09.01.2013	Tripping injury	Distribution of fish on board
04.05.2013	Shock / crush injury	Other work / monitoring of loading / unloading operations
02.01.2015	Tripping injury	Unknown
30.03.2016	Chemical injury	Unknown
08.05.2016	Shock / crush injury	Unknown
12.05.2016	Shock / crush injury	Packaging and storage of frozen fish in cargo
12.05.2016	Shock / crush injury	Unknown
29.08.2016	Shock / crush injury	Unknown
31.10.2016	Shock / crush injury	Unknown
13.09.2017	Tripping injury	Unknown
07.10.2017	Shock / crush injury	Distribution of fish on board
19.10.2017	Shock / crush injury	Packaging and storage of frozen fish in cargo
03.11.2017	Shock / crush injury	Other work / monitoring of loading / unloading operations
10.11.2017	Shock / crush injury	Distribution of fish on board
11.11.2017	Stick / cutting injury	Unknown
17.12.2017	Poisoning	Packaging and storage of frozen fish in cargo
15.02.2018	Tripping injury	Distribution of fish on board
12.03.2018	Shock / crush injury	Harvesting treatment
15.08.2018	Poisoning	Unknown
13.11.2018	Shock / crush injury	Unknown
12.06.2019	Load Injury	Unknown
28.06.2019	Tripping injury	Unknown
19.08.2019	Tripping injury	Unknown
18.12.2019	Chemical injury	Unknown

Table 3: Statistics for injuries happening in freeze room on fishing vessels, from Norwegian Maritime Authority [Personal injuries - 1981-2019]

2.4 Industrial Equipment

2.4.1 Programmable Logical Controller

PLC stands for Programmable Logical Controller and it is an industrial computer which is adapted for the control of manufacturing processes. PLC was introduced by Richard Morley in late 1960s. Initially the PLC was a replacement for panels of relays. The use of relays was time consuming, challenging and not very space efficient.

A PLC does need some equipment. To install a PLC you need a CPU module and input/output devices called I/O. The CPU communicates with the I/O. The PLC also require a power supply.[22]

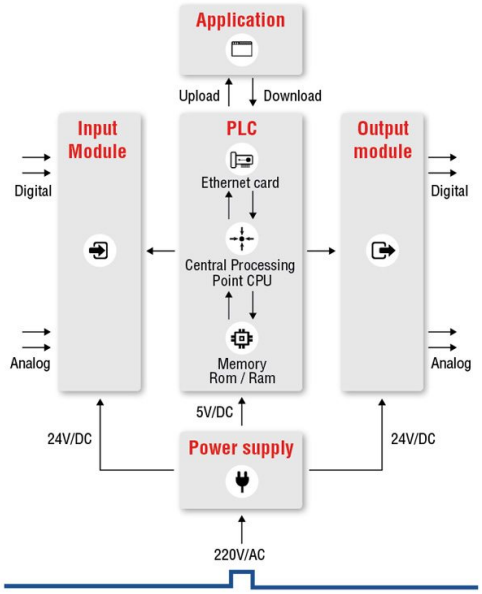


Figure 6: PLC system [37]

2.4.1.1 Programming Language, IEC 61131-3 standard

IEC 61131-3 standard is the international standard for programming languages used in PLCs. PLCs from different manufacturers can be programmed in many different ways, and the most used languages is listed below.

- Ladder Diagrams (LD) are specialized schematics. They are called "ladder" diagrams because they resemble a ladder, with two vertical rails (supply power) and as many "rungs" (horizontal lines) as there are control circuits to represent.
- Structured Text (ST) is a high level language that is block structured and syntactically resembles pascal on which it is based.
- Function Block Diagram (FBD) is a graphical language, that can describe the function between input variables and output variables. A function is described as a set of elementary blocks. [24]

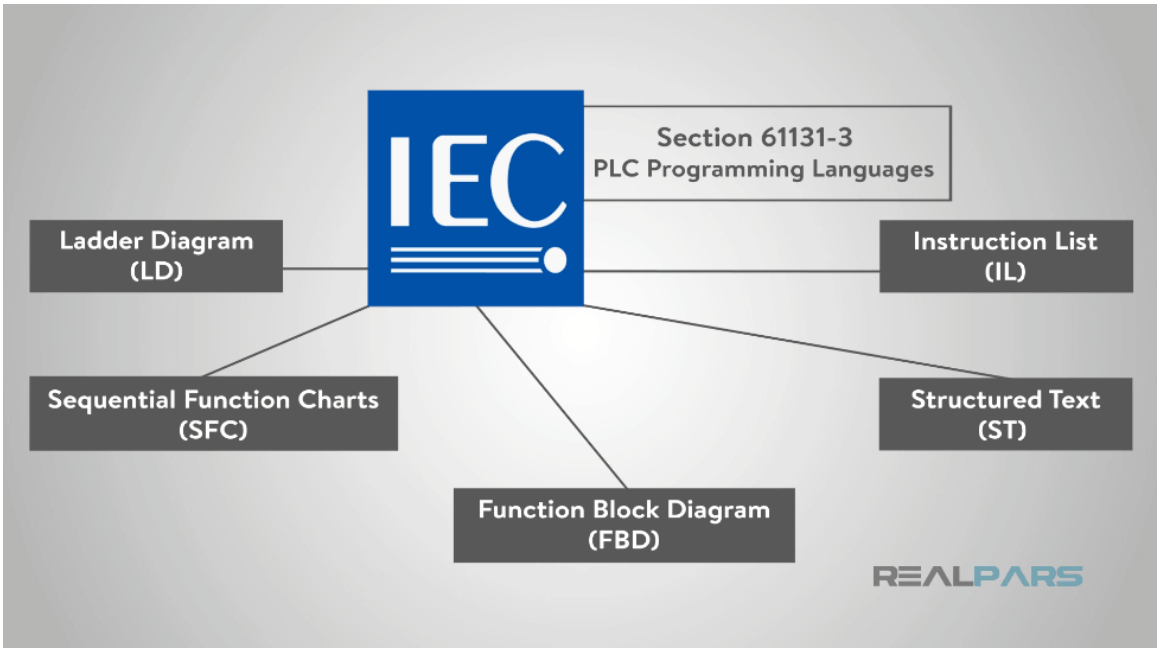


Figure 7: Programming languages [4]

2.4.2 Human-Machine Interface

HMI is used in the industry to control and monitor machines. A very common HMI that almost every person has used, is an ATM machine. The screen and push buttons allows you to operate the machine to dispense a certain amount of money or deposit money.

Industrial HMI will many times be in a form of a screen, often touch screens. An operator or maintenance personnel can operate and monitor the machine from the HMI. The HMI may include information such as temperature, pressure, process stats and material counts. An HMI screen can be connected to a PLC, and monitor several systems at the same time, as shown in the picture below. [23]

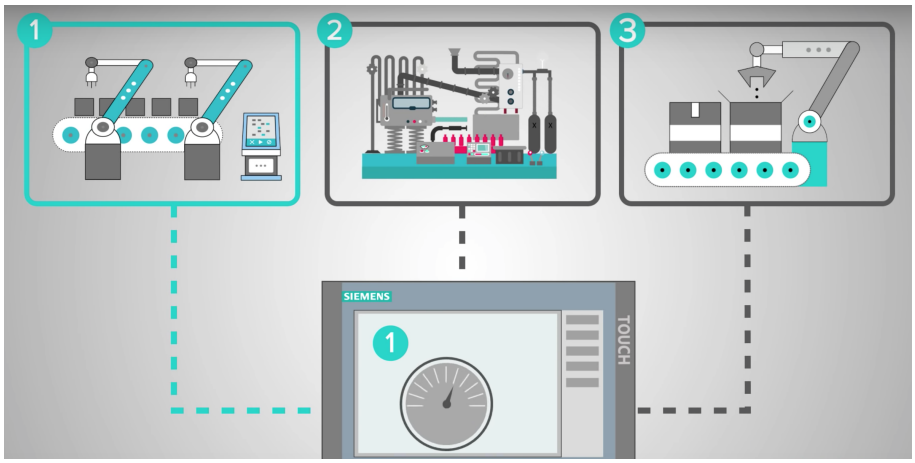


Figure 8: HMI system [23]

The picture and information above, is gathered from an educational video from GalcoTV. If more information is desirable about HMI's follow the link and watch the video [What is an (HMI) Human Machine Interface? - A Galco TV Tech Tip]

2.4.2.1 The evolution of the HMI

The evolution of the HMI has changed dramatically the last years, and has gone from push buttons to touch screens, from text-based to graphical and from manual to automated control. This evolution has brought along concepts like "Visualization", Graphical user interface, user friendly and much more. [14]

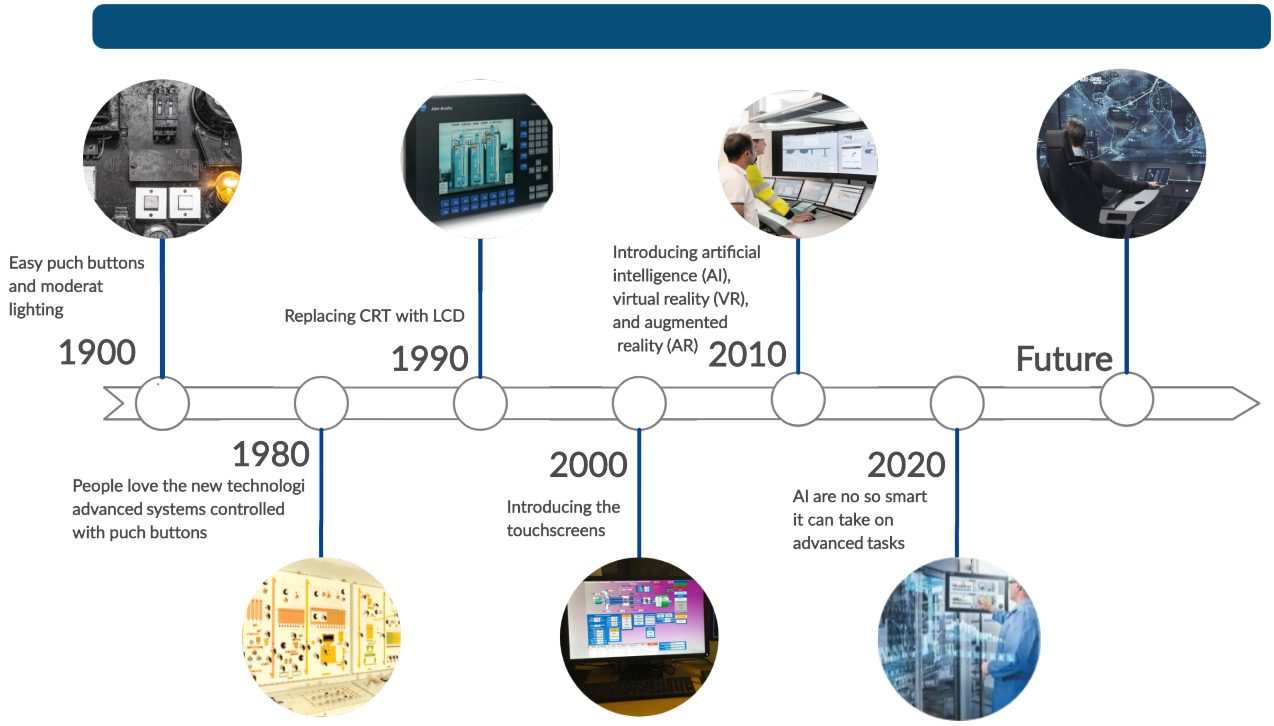


Figure 9: HMI evolution
[15] [18] [33] [9] [44] [10]

2.5 Graphical user interface (GUI)

A GUI (Graphical User Interface) is a type of graphical visualisation interface which makes it possible for humans to interact with systems, machines and other devices. These types of interactions is represented in form of pictures, buttons, input fields and other graphical elements. With GUI's an user interacts directly with the device and not by programming or via textual commands. Almost everyone interacts with GUI's in there daily life. Either you use your smartphone, computer or withdrawal at ATM's. [29]

Some commonly known GUI's most people use:

➔ Android

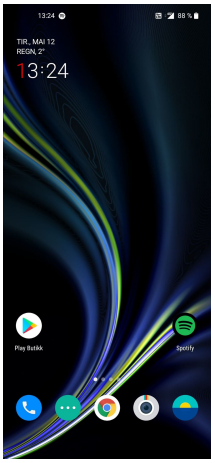


Figure 10: Android GUI

➔ Apple iOS

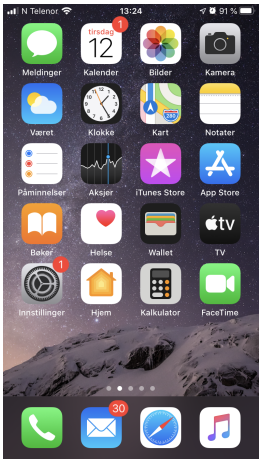


Figure 11: IOS GUI

2.5.1 Industrial Remote controls

Industrial remote controls comes in many different wrappings and usages. In this thesis the main aspects of industrial remote controllers will be based in wireless handheld controllers.

A wireless remote control is a safe and convenient way of controlling a piece of machinery or system. Most wireless remote controls is programmable and therefore programmed to desired usage. One of the most obvious benefits of a wireless controller is that you don't need to move back and forth to the machine or control panel to operate the machine or system. By doing this, the operator becomes mobile and can operate the machine or system at desired position or by doing other work. A wireless controller will also not be in the operators way, like cable bound systems. By doing so one can avoid all maintenance needed due to damage or corrosion and reduces the safety hazard, such as tripping hazard.[36]

Figure 12: Industrial Remote controls from Tele-Radio [35]

2.6 Communication protocols

2.6.1 Ethernet- protocol

Ethernet is the most common technology used in local are networks and is specified in the IEEE 802.3 standard. Ethernet was originally developed by Xerox and further by Xerox, DEC and Intel. Networks using Ethernet network technology can consist of either coaxial cables, twisted pair cables, fiber optic cables, or wireless called WLAN. The technology typically allows data transfer at speeds of 10 Mbps [42].

2.6.2 Ethernet/IP

Ethernet/IP is an industrial network protocol that adapts common industrial protocols to standard Ethernet. It was introduced in early 2000 to most industrial Ethernet solutions. Part of the reason is based on open technology. [41]

2.7 Maritime electrical installation

Norwegian directorate for civil protection [dsb] has a given set of standard that are relevant to this bachelor. See link to Regulations relating to maritime electrical installation.

Chapter V – Supplement about safety of fishing vessels of 15 meters in length and over – Precautions against shock, fire and other hazards of electrical origin. [5]

2.8 Wiring

When working with electrical systems it's important to choose the correct cabling type and size. Choosing the right type of cable is important, because of the impact the cable has to withstand from the environment and the safety regarding fire other electrical related accidents. The cable size is vital in an electrical system because of safety. The cable needs to be big enough to withstand the heat generated by the current flowing through the cable.

Wiring for AC and/or DC electrical circuits, colour codes are crucial for identifying the individual wires. IEC, AC: Most of Europe abides by IEC (International Electrotechnical Commission) wiring color codes for AC branch circuits. [2]

2.9 HMI Guidelines

ISA 101 seems to be the most active development in recent HMI standards, world wide. ISA is known as The International Society of Automation, formerly known as The Instrumentation, Systems, and Automation Society.

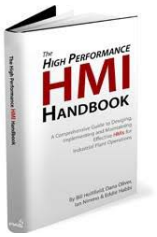


Figure 13: HMI-Handbook [1]

Modern human machine interfaces(HMI) provide means to the operators to see, touch and control high stress industrial processes through touch screen displays. Two major factors on HMI screens;

1. The screen must be able to hold operators attention with maximum display clarity
2. The design must allow a person with no training or little experience to be able to successfully operate a machine.

2.9.1 Background Color

Warm colors such as red, yellow and orange are colors that will draw one´s attention to particular areas of the HMI display. Use of such warm colors is not relevant for large areas of the screen. Cool colors make better backgrounds and theme colors, because of their tendency towards balanced representation of feelings. HMI graphic should have a dull background, grey is the preferable one. Animation and crossing lines should be avoided so that the operator does not get distracted from important data. Primary colors such as red, green, blue should never be used as background, cause of their ability to cause a glare.

2.9.2 Color Choice For Objects

According to the HMI handbook and HMI design Standard there are few colors that should specifically be used for certain operations. The use of colors for the indicators should be:

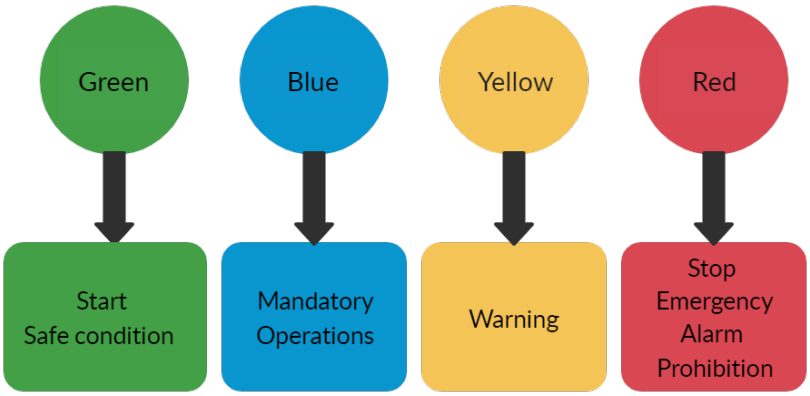


Figure 14: Colors

2.9.3 Text

Texts on the HMI screen is the simplest way to relay information to the user, but the screen should contain minimum amount of text. Choices of text should be in a readable format, for optimal user experience.

2.9.4 Alarm

Alarm information is the most important part in the HMI screen design. An operator should not be uncertain when an alarm is active. Colors such as red and yellow attract one's attention. It is necessary that such colors are used for alarms.

2.9.5 Layout

A screen layout is important for a good HMI display. A human normally scans an HMI screen as any other regular screen, starting from the top left corner to right and then down the screen. The important objects of a system should be placed in an area within the page where the users attention easily goes. The alarms should pop up in the middle of the screen, and key data on the center right of the page.[11]

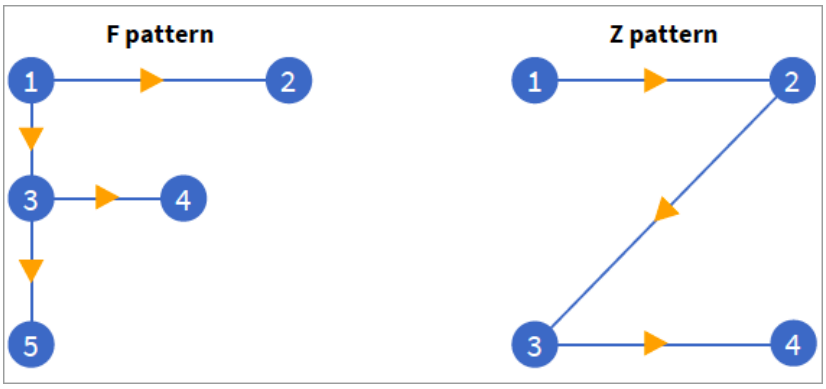


Figure 15: Eye Pattern [3]

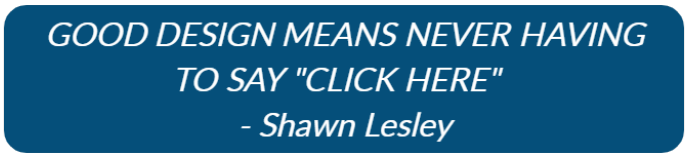


Figure 16: Design

3 Approach

Chapter three provides an understanding of what has been important to the project regarding the desired quality, requirements and specifications. This includes group organization and how we have chosen to solve the task.

3.1 Approach due to the Covid-19

In the spring of 2020 a pandemic emerged, Covid-19, influencing the thesis. Due to the lack of a risk analysis to a pandemic, this had to be conducted during the thesis. The analysis of Covid-19 became a constant analysis with regard to the shifting news picture. All members had to stay updated to the shifting news pictures, measurements taken by NTNU and the Norwegian government. The total risk analysis can be read at attachment [K] and the implementations due to Covid-19 is elaborated in section [6.5] implementation.

3.2 Project organization

The group has selected a group leader and a group secretary. The group leader in this case is responsible for ensuring that all assigned tasks are completed, and has an overview of what has not been done and what needs to be done. He will be our main contact person throughout the project. To manage disagreements and working hours throughout the project, a Cooperation Agreement was made.[A]

The group secretary is responsible for the main report. The secretary is also responsible for organising meetings and will be taking the lead of running the team when the leader is unable to attend the meeting

Apart from this, all members are responsible for ensuring that all tasks assigned to them are completed. In an early phase of the project, a project plan was made in Instagantt, to ensure pathway and end stop for the project. This plan is detailed and includes all tasks each team member is assigned to. To see the full Instagantt plan see attachment [C]. The project report will be processed throughout the project.

Once a week, as long as there are new information, there will be held a meeting with the supervisor. During the weekly meetings the topics will be around status of the project, problems we have encountered and new solutions. To get a more elaborated approach view pre-project [12].

3.3 Project description

Optimar is in the process of delivering equipment to the new vessel, Geir III. Geir III will be an improved version of the previous vessel, Geir II. One of the goals of this new vessel is to improve the safety of the workers.

Large freezer compartments are normally located at the bottom deck and the accessibility to radio or other workers are often low to non existing. When an injury occurs, time is of the essence. If a worker is crucially injured there should be a way of contacting bridge personnel and/or medical help. On the other hand if the worker is unconscious the system should automatically report an incident to bridge personnel.

The task will be to develop an accommodating safety system that encourages the workers to change their habits, and take in use new routines.

The approach of the task is sectioned in main parts. Testing, modifying and assembly will happen simultaneously

- Specifying main description
- Brainstorming functions
- Hardware
- Software
- Prototype
- Reviews and testing

3.3.1 Specifying main description

The ideal solution is a safety system where workers is obligated to use a handheld transmitter that is brought into the freezer when entering. The handheld transmitter is used by the worker to call for help if needed. The worker also has to press a button on the device every given amount of time, if the button is not pressed, an alarm will be triggered. To control the system, two HMI screens shall be used, one at the entrance of the freezer room and one at the bridge. Outside the freezer entrance there shall be a charging station for the handheld transmitter.

Finally, a user-friendly interface should be designed where history can be viewed. This user interface should give an overview of who works in the freezer at any given time. If the worker is inside the freezer and calls for help with the handheld transmitter, an alarm will go off on the user interface. This alarm will also be triggered if the worker inside the freezer fails to press the button within the given time frame.

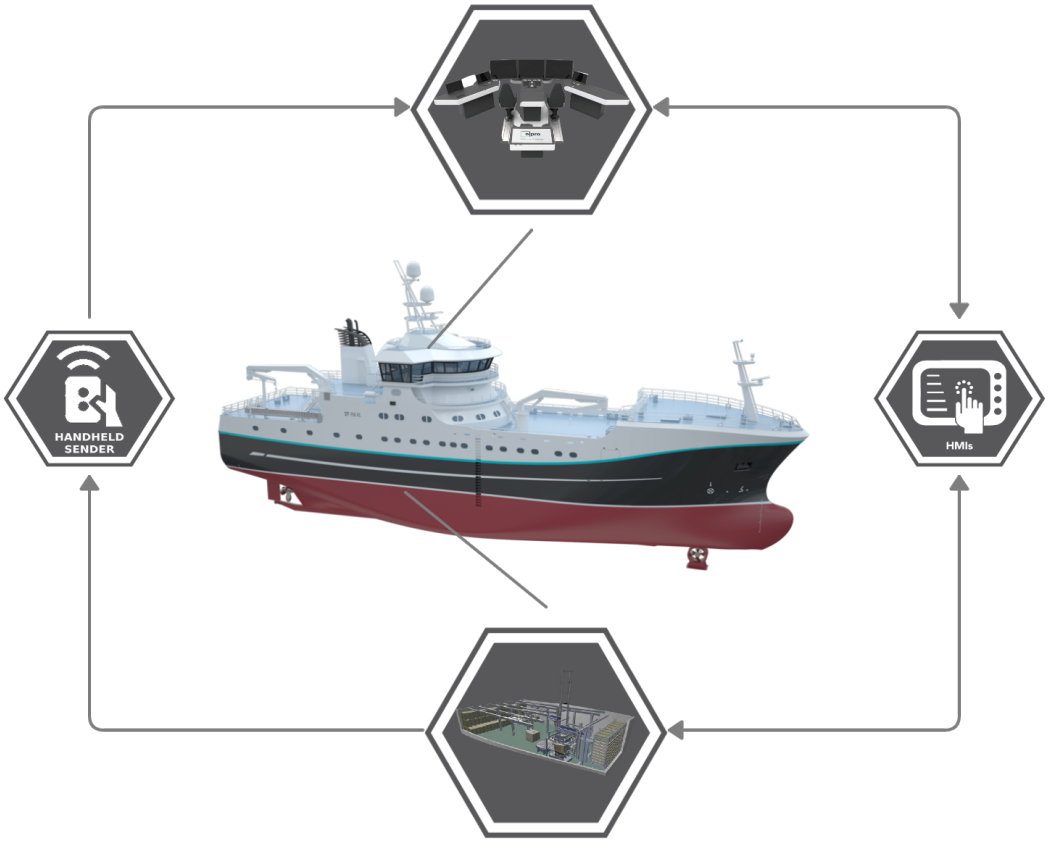


Figure 17: Sketch [7]

3.3.2 Brainstorming functions

Must have	Should have	Could have
24V separate powered system	Inviting and user friendly gui	Logging of alarms
Portable, wireless and rechargeable transmitter	Transmitter for one hand use	Vibrate or light to signal worker to report
Alarm if workers fail to report	Alarm with light and sound	Phone message for sleeping health personnel
Alarm if workers reports a injury	Alarm with light and sound	Phone massage for sleeping health personnel
Two HMI screens, bridge and freezer	Quick view GUI for bridge	UPS/battery if power disappears
Password protected admin page	Possibility to change timers and add workers	Add possible phone messages

Table 4: Project functions

Function	Description	Reason
Admin min mode/page	Password protected mode	Adjustment of div. variables and add users
Alarm log	System for logging all alarms back in time	Event overview
Worker nr.2	"Second worker logging in"	Simple and user friendly
Overview of workers displayed	A menu when "logging" in to freezer to select given worker	Overview of who was/is inside freezer

Table 5: GUI functions

3.3.3 Hardware

There is a lot of equipment that is necessary to carry out a project of this scale. This sub chapter takes care of the main components needed to build a system explained and brainstormed in the two sub chapters above. Chapter 4 will contain a more specific material list with manufacturer and explanation of why the given component was chosen.

3.3.3.1 Cable size and color

Small electronics works with a power supply at 12v or 24v. These voltages are so low that a cross section at 0.75 is ideal. Other measurements that plays a role in choosing the thickness of the cable is how many cables that are going to lay next to each other. More cables next to each other will conduct more heat, but with only 12v or 24v this will not be an issue.

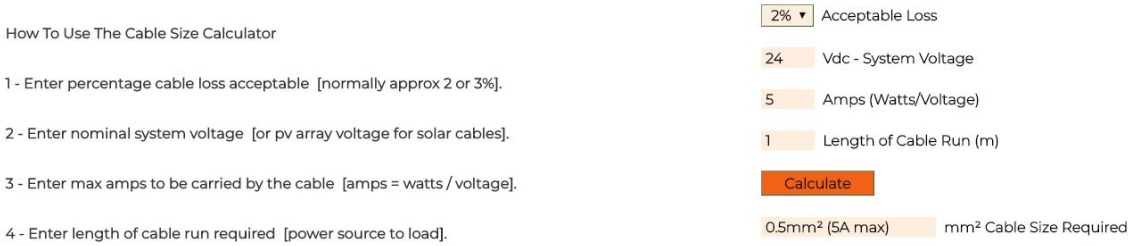


Figure 18: Cable size [31]

Rounding up to cable sizes is 0.75mm2, 1.5mm2, 2.5mm2, etc.. [32]

When it comes to color the group will follow the standards from Optimar

Earthing	Green and yellow
230V +	Blue
230V -	Brown
24V +	Red
24V -	White
Signal	Orange

Table 6: Cable color

Logic components

Component	Usage	Amount
PLC	Programmable logic controller, used for the logic of the system	1
HMI screen	To display events and to control freezer	2
Ethernet switch	For communication between PLC and HMI screens	1
Power supply	To power the system	2
Relay	Trigger input on receiver	2

Table 7: Logic components

Wireless transmitter and receiver

Component	Usage	Amount
Wireless handheld transmitter	Used inside freezer by worker to acknowledge	1
Wireless receiver	To communicate with the handheld transmitter and PLC	1
Charger	User-friendly, no need to change battery	1
Antenna	Antenna to receive signal from handheld transmitter. Can withstand the low temperature better than receiver	1

Table 8: Wireless transmitter and receive

Control cabinet

Component	Usage	Amount
Terminal blocks 230V	The interface between what is placed inside the cabinet	x
Terminal blocks 24V	Order, overview and safety	x
Terminal blocks earth	Common ground point	x
Terminal blocks end plate	Electrical Safety	x
Terminal blocks numbering	Order, overview and safety	x
Cable gates (slotted channel)	Order, overview and safety	x
Mounting rail	Mount equipment to cabinet	x

Table 9: Control cabinet

3.3.4 Software

There are different types of software that will be used in the thesis for different tasks, more about the given software in section [4.3.2]. This sub chapter will focus on the approach of each software.

3.3.4.1 Electrical drawings

The electrical schematics will be constructed by gathering as much information about the different materials and their way of wiring. An electrical sketch will be made and again controlled when all materials arrives. Then a final drawing will be made, controlled by all group members before finalizing.

3.3.4.2 Graphical User Interface

Three versions of the GUI will be made, one by each group member. The GUI's will then be combined into one, giving the GUI the benefit of multiple choices in design patterns. By doing so all members would get familiar with Sysmac studio, and knowledge of designing a GUI will be gained.

Table [5] and [4] gives a function overview that all members will have to take into consideration when designing the GUI. All members creativity should float but within some restrictions. See chapter [7.1.1] for the different designs of the GUI and chapter [8.3] for the end result.

3.3.4.3 PLC Program

The PLC program will be conducted by creating a flow chart describing the flow of information and behavior, and then the code will be constructed based on these flowcharts. The code will be programmed based on the PLC language, structured text.

The license gathered for the PLC program does not support version control or a collaboration systems, like git. The work around will be to program the PLC based on functions, function blocks and programs working in parallel, making it easy for collaborating and combining programs.

3.3.5 Prototype

During the pre-project phase of the thesis it was decided to design, build and manufacture a prototype of the system. The prototype will be a display of the completed product. The main goal of the prototype is to design and create a compact control cabinet, that requires minimal effort for installation.

- Connect the 230 V to the given terminal blocks
- Route an Ethernet cable and mount the HMI screen at the bridge with a power supply.
- Mount the antenna in the freezer

3.4 Reviews

An important part of the thesis is the review and test phase. During the review and test phase the focus will be on discovering faults, shortcomings and qualities. This to ensure the quality of the final product.

➥ Hardware

Review of hardware is necessary to ensure that the entire system with all the different parts works together properly.

➥ Software

A Software review is needed to avoid errors in the code. A systematic examination of the code, and an inspection to find defects.

➥ Design

To avoid collision in the electrical cabinet. If there is a case where the system needs maintenance or service, it is necessary that equipment can easily be replaced without any major cabinet changes.

The design of the GUI should be user friendly and reliable.

Therefore, our design review will consist of;

① Physical tests

② Engineering simulations

③ Examinations

3.5 Testing

Throughout the project, several tests has to be done. All tools and equipment will be tested before being used.

3.5.1 HMI

Based on the different GUI designs, we must test which one works optimally for the user. With regard to the visibility of different buttons, screen brightness and whether it is user friendly.

3.5.2 PLC

Based on given functions and logic of the system, it's important to constantly test new functions. It will then be easier to troubleshoot if something goes wrong. It's also important to test that the logic is working as desired with the different equipments.

3.5.3 Handheld transmitter and receiver

The handheld transmitter must be tested in several robust tests. It will be tested to see if buttons, buzzer and LED's works optimally in low temperature environments. The device should sit properly on a worker while moving and doing heavy work, without being an annoyance.

3.5.4 Communication

Before everything is assembled in the electrical cabinet, the communication between each component unit would have to be tested. For our system to work, each unit must communicate with each other in some way. Below is a step-by-step overview of what tests that will be done;

- Communication between Sysmac Studio and PLC
- Communication between Sysmac Studio and HMI
- Communication between HMI and PLC
- Communication between Receiver and PLC
- Communication between Receiver and handheld transmitter

3.5.5 Electrical cabinet

It is important to measure to see if all of the equipment gets the power it requires, so that the components do not get damaged. Each group member should go through the connection of the cabinet and check the voltage values with a voltmeter to test the connections and the power supplied to the components.

4 Materials

This chapter deals with the choice of materials, why these materials were chosen, and how they met the expectations and requirements of the group and Optimar.

4.1 Selection of materials

During the pre-project[12] research regarding different manufactures and parts needed for this project was conducted. A list of parts needed can be read at [7] [??] [??]. Furthermore the group had meetings with Optimar discussing subjects as specifying the thesis, parts needed and manufacturers they were using.

After a lot of research and discussion, a list of components with optional handheld transmitters was sent to Optimar, refers to list at attachment [I]. Optimar has a partnership with Omron Electronics and wanted the group to choose most of the parts needed from them. Regarding to one of the main component (handheld transmitter) a proper research was required. We were told that the company Tele-Radio AS had possible units that could work in our system. In terms of budgeting, no specific requirements were given.

4.1.1 PLC - NX1P2-9024DT1

To control the logistics of this type of system a PLC is required. The NX1P2-9024DT1 was recommended to the group by Optimar. This PLC is relatively cheap and has all specifications needed. The PLC has Ethernet/IP, SD card support and I/O that meets the groups requirements. The PLC is a NX model which means it can be programmed by the Sysmac Studio IDE.

Figure 19: NX1P2-9024DT1 [20]

4.1.2 HMI screen - NA5-7W001B

In the bachelor thesis description, it states that two HMI screens is needed. The HMI screens that Optimar recommended to the group was the NA5-7W001B. This is the smallest and the cheapest screen in the NA class of HMI screens. The GUI will have a limited amount of information to display, and because of this the group and Optimar concluded that the 7 inch screen will be big enough for this project. The screen is an NA model, which means it also can be programmed by the Sysmac Studio IDE, and is directly compatible with the chosen PLC.

Figure 20: NA5-7W001B [19]

4.1.3 Ethernet switch

The PLC that was chosen is only equipped with one Ethernet/IP port. This led to the need of an Ethernet switch to serve the two HMI screens needed. The FL SFNB 5TX ethernet switch from Phoenix Contact with 5 ports was chosen due to the possible need of scalability in the future.

4.1.4 Power supply

To supply the system with power, a power supply must be chosen. The power supply needs to power a HMI screen,PLC, Ethernet switch and a receiver module. After a discussion with Omron, they recommended a 120w power supply. The S8VK-G12024 power supply satisfies this specification, and chosen for this project. An additional power supply of the same model will also be used to supply the HMI screen, located on the bridge, with power.

4.2 Possible handheld transmitter and receiver

When choosing handheld transmitter and receiver a set of criteria were set by Optimar. The importance of the transmitter was it's capability to work in the temperature of a freezer room, be rechargeable, durable, easy to use and with the possibility to notify workers to acknowledge. The receiver needed to correspond with a given transmitter.

Research around handheld transmitter was concluded, and a list of handheld transmitters and their specifications was sent to Optimar for consideration. A list with specifications of the handheld transmitters that was considered for use and the chosen device can be read underneath.

4.2.1 Comparing technical features

Product	**Rf-solution**	**FSL Electronics**	**Tele-radio**
			
Handheld	✓	✓	✓
Cooperation	×	×	✓
Range	up to 2000m	up to 300m	Long range
Operating temp	-10 $\rightharpoonup$ 50C	10 $\rightharpoonup$ 50C	-20 $\rightharpoonup$ 55C
IP rating	IP68	IP55	IP66
Rechargeable	×	✓	✓
Remote antenna	✓	✓	✓
Led indicator	×	✓	✓
Vibration	Unknown	Unknown	×
Buzzer	Unknown	Unknown	✓
Fulfilling criteria	×	×	✓

Table 10: Comparing technical features [26] [25]

4.2.2 Chosen handheld transmitter

4.2.2.1 Tele-radio - Tiger G2

Tele-radio and their Tiger G2 series became the chosen handheld transmitter with corresponding receiver. Several aspects were weighted when choosing handheld transmitter, [4.2.1]. The main reason for choosing Tele-radio and their Tiger G2 series was the temperature certification. Tiger G2 has 8 programmable buttons, LED lights and buzzer functionality. The receiver has plenty of inputs and outputs for communication. Tele-radio do also deliver custom solutions were receiver can be pre-programmed and transmitter tailored to the needs of the customer.

Optimar has cooperated with Tele-radio in their previous projects, giving them discounts and tailored solutions. All of the aspects above together with the functionality of the transmitter and receiver resulted in the selection of Tele-radio and the Tiger G2 series.

(a) Tiger G2

(b) Tiger receiver [34]

4.2.3 Considered handheld transmitters

4.2.3.1 RF Solutions

The handheld transmitter from RF Solution didn't reach the technical standards, and therefore was not the chosen handheld transmitter. Optimar did not have a cooperation with Rf-solution and no previous experience with the product. At the same time the device was not rechargeable and had a low operating temperature tolerance.

4.2.3.2 FSL Electronics

The handheld transmitter from FSL Electronics were considered because of it's design. Optimar liked the watch design and simple button layout. The problem with FSL Electronics was mainly the operating temperature. The device wasn't made to operate in sub-zero temperatures.

Figure 22: Rf-solution [26]

Figure 23: FSL Electronics [25]

4.3 Control cabinet and components

The most important specification when choosing the control cabinet is the size and that the cabinet is made out of a stainless steel. To ensure that the cabinet is big enough we chose a cabinet with a height of 600mm, a width of 380mm and a depth of 215mm. If the group struggles to find a control cabinet at an affordable price, Optimar offered to give away one of their cabinets to us.

Figure 24: Control Cabinet [28]

4.3.1 Cabinet materials

The given materials are needed to mount or keep the control cabinet organized. All materials are given from Optimar and their cabinet making department. The given pictures are just a visual view of the products. From left to right: Terminal blocks, slotted channels and mounting rails.

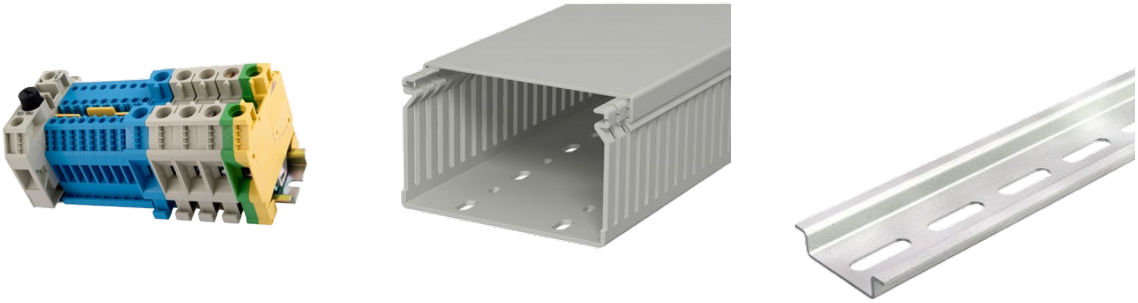


Figure 25: Cabinet materials [12] [6] [30]

Hardware material

Manufacturer	Component	Model	Quantity/size
Omron	Controller/PLC	NX1P2-9024DT1	1
Omron	HMI screen	NA5-7W001B	2
Phoenix Contact	Ethernet switch	FL SWITCH SFNB 5TX	1
Phoenix Contact	Relay socket	PLC-BSC-24DC/21	2
Phoenix Contact	Single relay	REL-MR-24DC/21	2
Omron	Power supply	S8VK-G12024	2
Tele-radio	Handheld sender	Tiger G2	1
Tele-radio	Antenna	1/4-433K1	1
Tele-radio	Receiver	Tiger receiver	1
Phoenix Contact	Terminal Blocks	Earthing	2
Rittal	Cabinet	Stainless steal	600x380x210 mm
Phoenix Contact	Terminal Blocks	Normal	6
Obo bettermann	Slotted channel	Gray PVC 50x60 with lid	ca 2m
EFA	Mounting rails	TS 35 Hullet	ca 0,5 m
Unknown	PTFE spiral hose	Serie SBPTFE	ca 0,2 m
HelaDuct	Flexible cable protection	HelaDuct Flex	ca 0,3 m
Unknown	Yellow/green cable	1,5 mm^2	ca 0,5 m
Unknown	Brown cable	1,5 mm^2	ca 0,3 m
Unknown	Blue cable	1,5 mm^2	ca 0,3 m
Unknown	Black cable	0,75 mm^2	ca 02 m
Unknown	Red cable	0,75 mm^2	ca 2 m
Unknown	Orange cable	0,75 mm^2	ca 1 m

Table 11: Specific material list

4.3.2 Software

There are different types of software used in the thesis for different tasks.

Asana and Instagantt: Instagantt together with Asana was used in order to keep track of all the assignments for the bachelor thesis. Asana and Instagantt were the chosen software for keeping track of all the assignments because it was recommended by earlier students and supervisors.

AutoCAD 2020 and AutoCAD Electrical 2020: AutoCAD 2020 is a widely used software to design almost everything. AutoCAD 2020 is the software tool Optimar uses to design and draw there electrical drawings. Optimar wanted the group to use Autocad 2020 and the electrical version for electrical drawings Autocad Electrical 2020. The group found it tricky using these software tools because there was few libraries for electrical components and a complex program to learn. After discussions with Optimar, the group and Optimar agreed to use Pcschematic.

Pcschematic Automation 40: Pcschematic is a program that the group has earlier experience with, through work and school. Because of the previous experience the group and Optimar agreed to do all electrical drawings in Pcschematic.

Sysmac Studio: Sysmac Studio is used to program all NX and NA devices from Omron. The chosen devices, PLC and HMI requires Sysmac Studio to be programmed, making Sysmac studio the chosen software for programming PLC and HMI.

Overleaf: Overleaf is a free web-based text editor for latex. This text editor was chosen because of its simplicity, cloud based storage and it's capability of real time editing with several users.

Software material

Manufacturer	Software	Version
Asana	Instagantt	2019
Asana	Asana	2019
PCShematic	Automation 40	2020
Autodesk	AutoCAD	2020
Autodesk	AutoCAD Electrical	2020
Omron	Sysmac studio	1.3
Overleaf	Overleaf	2020

Table 12: Specific software list

5 Design

This chapter will explain how the most essential parts have been used to create a finished product. The explanation underneath will take care of how both hardware and software was planned and designed for the finalized result.

5.1 Hardware

The prototype is created as a finished product, hence minimal work is needed to install the safety system. The design requires 4 minimal operations for it to function:

- Connect the cabinet to 230v
- Mount antenna in freezer room
- Route an ethernet cable to the bridge
- Mount the HMI screen with a power supply at the bridge

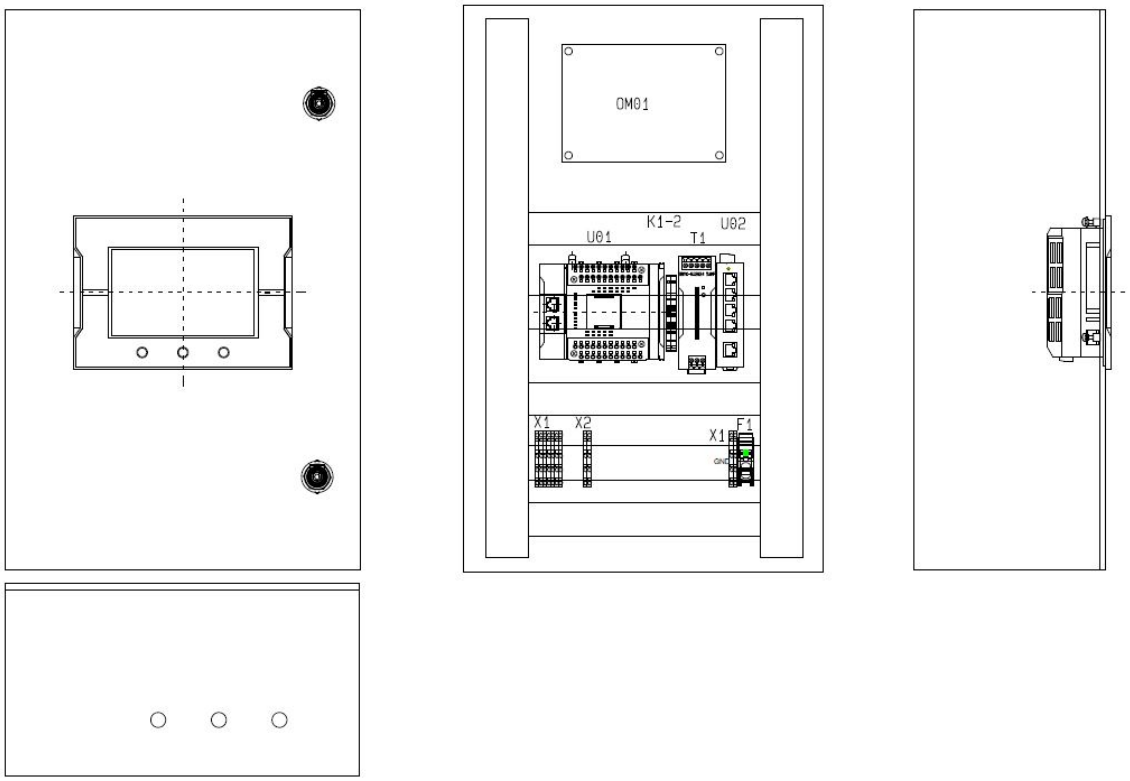


Figure 26: Cabinet schematics

(a) Front Cabinet

(b) Inside Cabinet

5.1.1 Placement of components in electrical cabinet

The components was placed in a way that made sense to the group. All the terminal blocks were placed at the bottom, since this is where all the cables comes through the cabinet. The PLC, power supply and Ethernet switch was placed in the middle of the cabinet because it's easily accessible to all the other components. The receiver was placed at the top, since it was the only unoccupied space left.

5.2 Software

To visualize and explain the system, two flow chart diagrams was used. One flowchart to show the overview sequence and one flowchart that also explains how the information flows between the PLC, the HMI screens and the handheld transmitter.

Overview flowchart

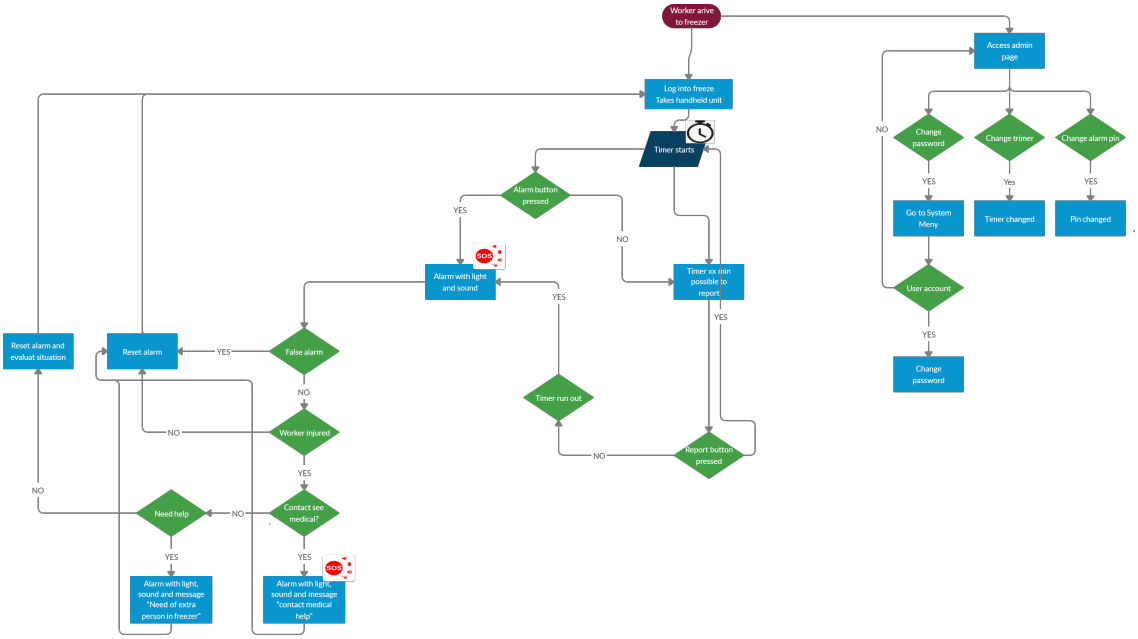


Figure 28: Overview flowchart

Overview information flow

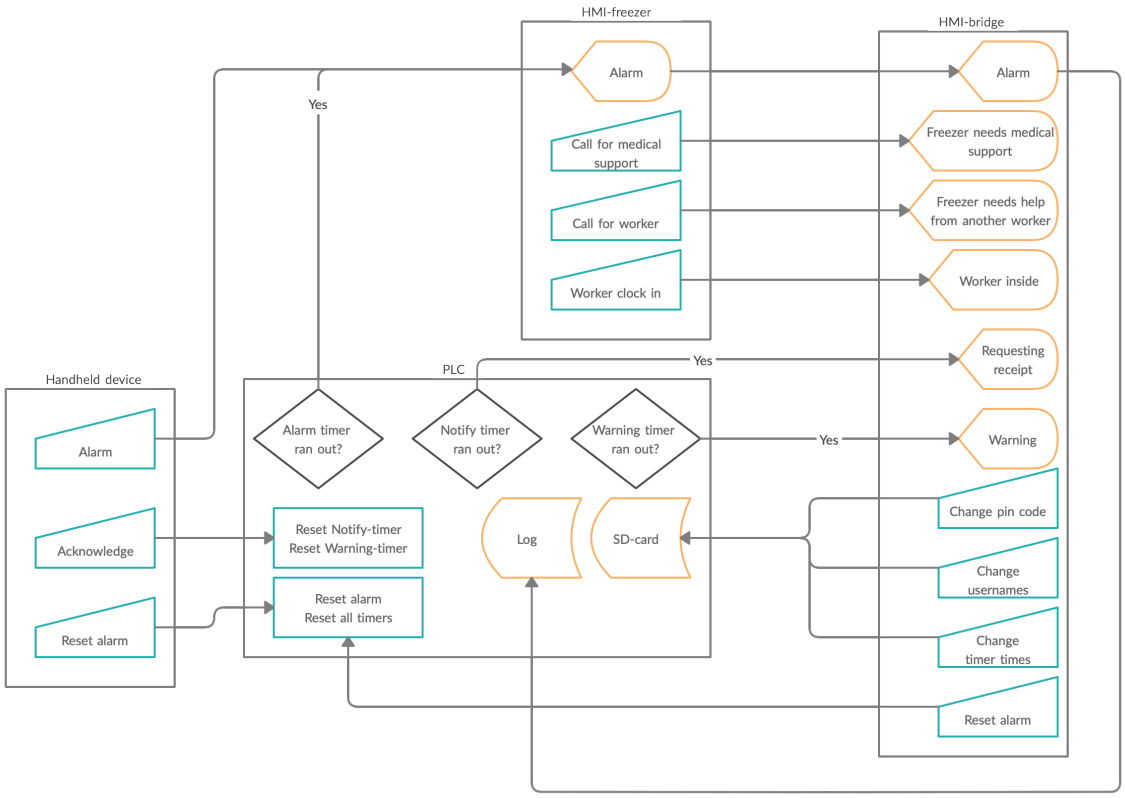


Figure 29: Overview information flow

6 Implementation

This chapter will explain how the approach, materials and design were implemented in the finalized product.

6.1 System overview

Figure [30] shows an overview of the safety system. The system consists of 2x HMI screens, a PLC with connecting software (Sysmac Studio), a receiver and a handheld transmitter. The connecting lines shows the information flow.

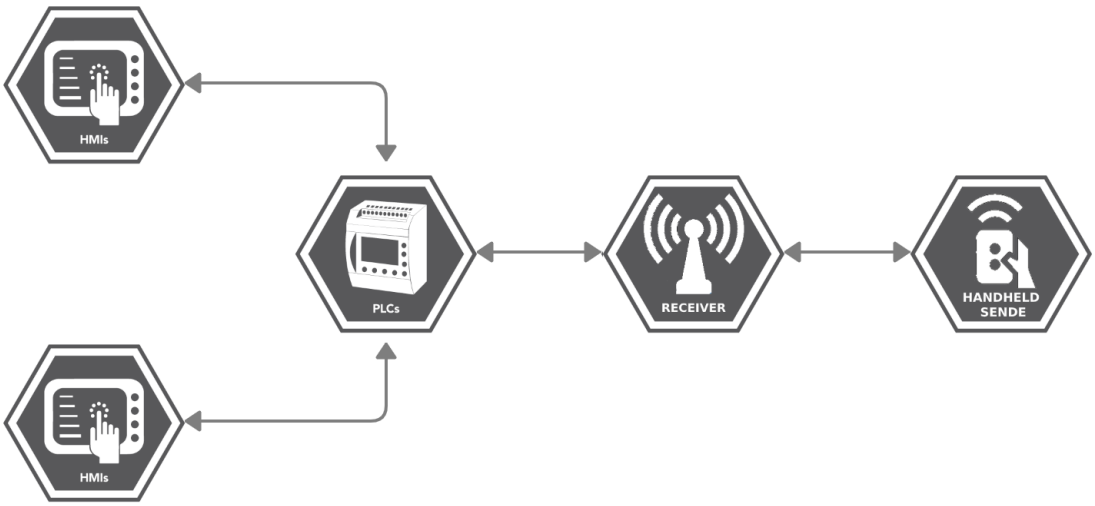


Figure 30: System overview [17]

6.2 Human Machine Interface

The human machine interface is a platform that makes it possible for the user to interface with the rest of the system. The graphical user interface consists of pages with buttons, lamps and other tools to edit or display global variables from the PLC.

For this project, two HMI's was used. The first interface is to be located outside the freezer-room. This HMI screen has two main tasks.

1. Check workers in and out of the freezer
2. Call for help if an accident occurs

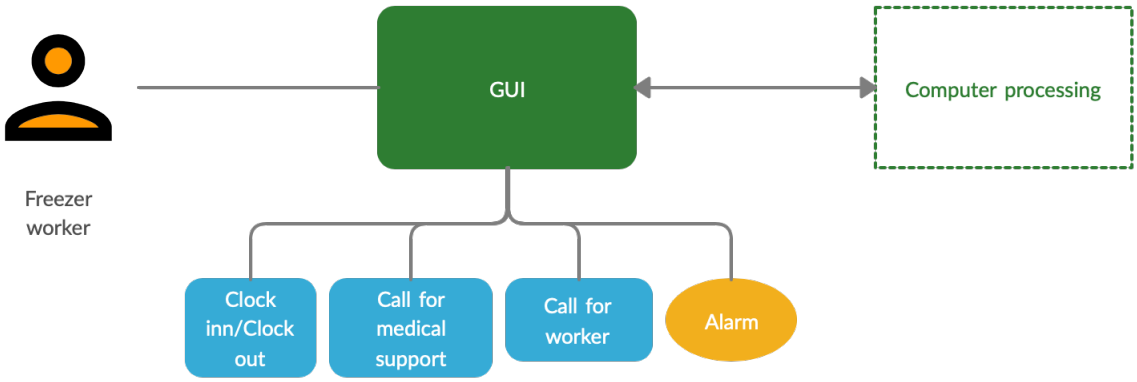


Figure 31: HMI outside freezer

The second interface is mainly used for administrative tasks, display warning and alarms to the workers on the bridge. In the administrative page one can manage users and timer variables. The lamps on the operation page displays if workers are inside the freezer, if a receipt is being requested by the PLC, if a warning occurs and if an alarm occurs. A pop-up window will be displayed if the worker inside the freezer is requesting assistance from another worker, or requesting medical support.

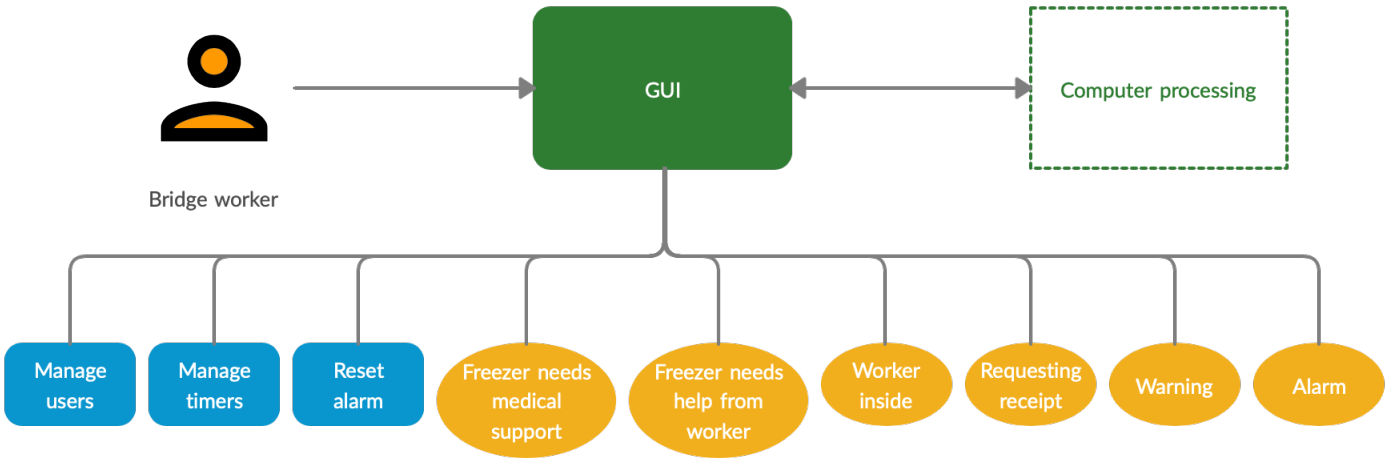


Figure 32: HMI on bridge

6.3 PLC

The PLC controls the logic of the system and is the main controlling unit. The PLC receives information from the two HMI screens and the receiver. This information is then processed and passed on to the given components or outputs that have been delegated.

The PLC used in the project has five main tasks:

1. To keep track of timers. Describing when to request a receipt from the user and when to sound the alarm.
2. To sign workers in/out to the system when they check in/out. Making sure only two workers can be logged in at a time and that they can log both in and out without errors occurring.
3. To share information between the HMI screens, making sure that both HMI screens can communicate with each other.
4. To read and write variables to the SD card. This is done so that usernames and timer variables is not lost after a potential reboot or power outage of the system.
5. To receive and send data to the receiver. Data received from the receiver consists

of two boolean values that correlates to the two buttons on the transmitter. Data that is sent to the receiver is two boolean values, saying whether or not to activate the buzzer and LEDs on the transmitter.

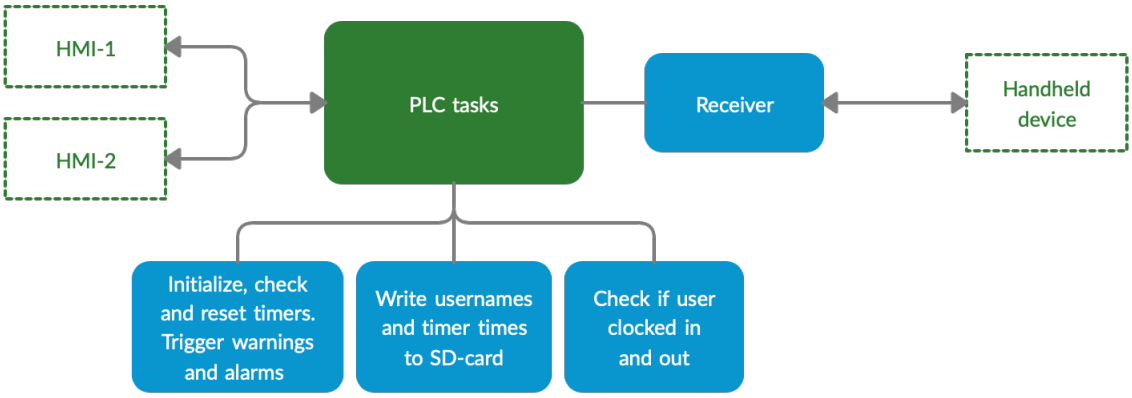


Figure 33: PLC tasks

6.4 Receiver and handheld transmitter

Both the receiver and the handheld transmitter is a pre-programmed system delivered by tele-radio. These two units together forms the link between the worker inside the freezer and the PLC logic.

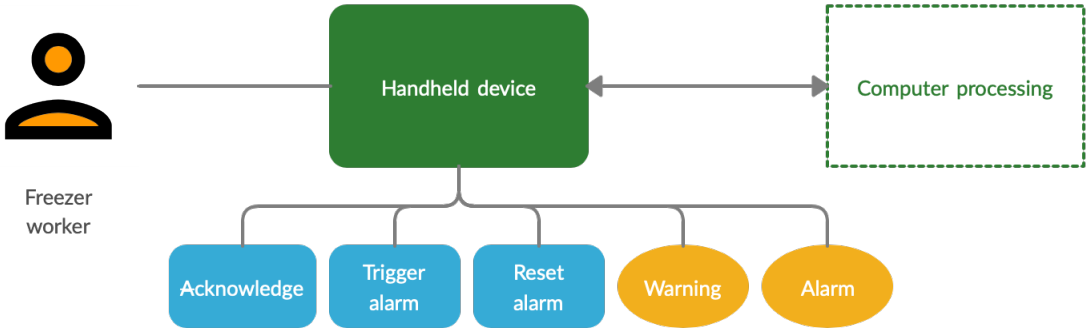


Figure 34: handheld transmitter

The receiver and transmitter consists of several parts:

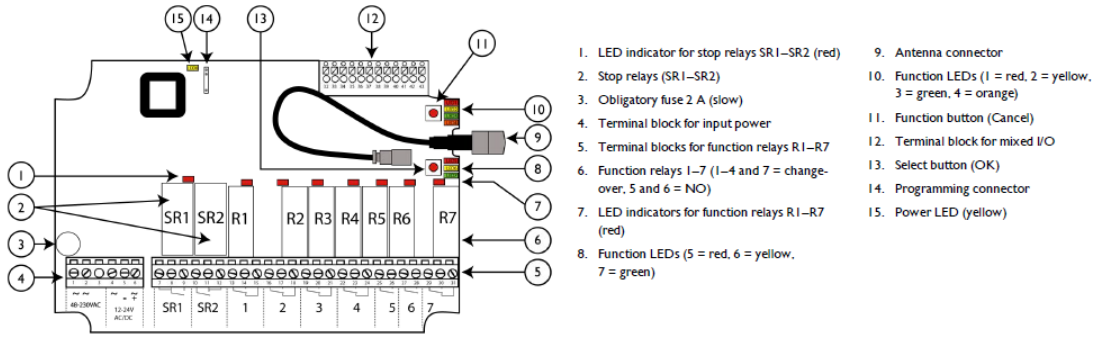


Figure 35: Receiver description

The main purpose of the receiver is an antenna receiving signal from the handheld transmitter. The signal from the transmitter is then converted to a mechanical operation making a corresponding relay close or open. The open or closed signal is then passed on to the input terminal on the PLC. There is also a couple of digital inputs on the receiver. These inputs is used to activate the buzzer and the LEDs on the transmitter.

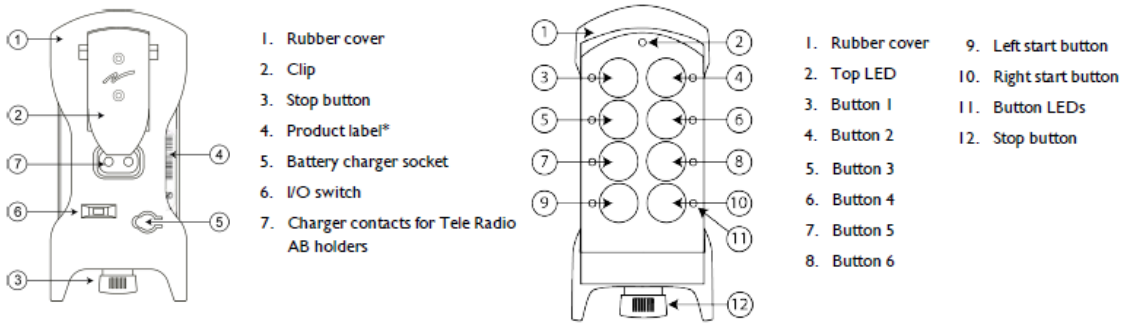


Figure 36: Transmitter description

The handheld transmitter have eight buttons, but two that are functional when in use. Button 4 is to acknowledge, and button 3 is to sound the alarm at the bridge. To cancel a false alarm, both buttons can be held down for three seconds.

6.5 Implementations due to corona

In the spring of 2020 a pandemic emerged, Covid-19, influencing the thesis. The pandemic made the group implement different measures to minimize it's influence. For the whole risk analysis see attachment [K]

6.5.1 Administratively

Figure 37: Administrative implementations

7 Testing and Reviews

This chapter covers all different tests and reviews the group has conducted. All changes that have been made due to testing and how this affected the end result.

7.1 Design

In the process of reviewing and testing the system, it was discovered that multiple changes would benefit the final result. These are small things like variable naming, readability, structure of the code and GUI user-friendliness.

7.1.1 Human Machine Interface

As mentioned in chapter 3, section [3.3.4.2] the approach was to program three different GUI's, one by each group member. All members made their own GUI design for both the freezer entrance and the bridge. This type of testing was done to find the most user-friendly GUI. The key to a successful HMI system requires a well-grounded definition and understanding of the operators. Our thoughts of characteristics for HMI after testing is explained underneath.

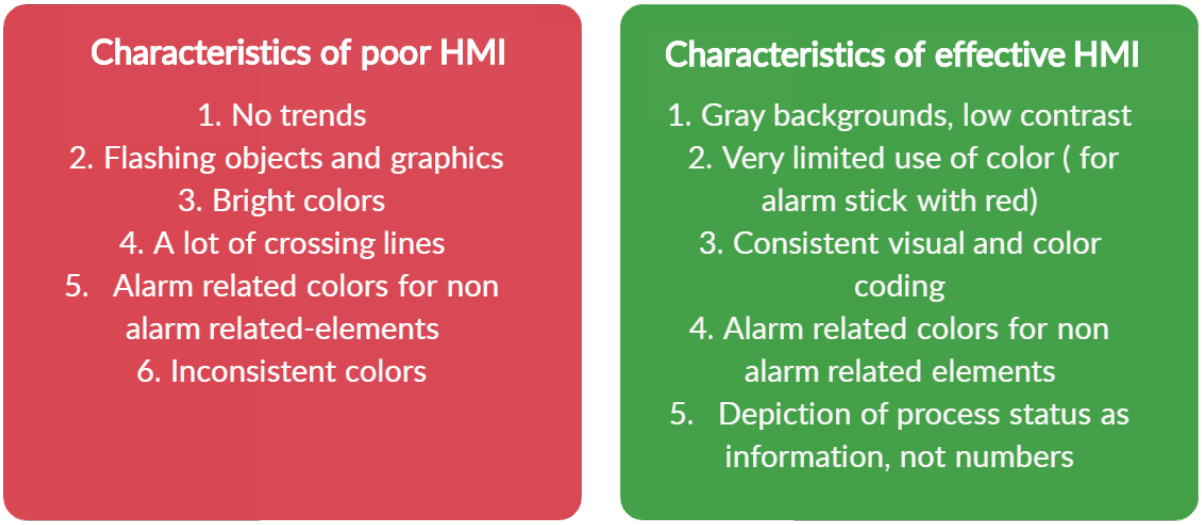
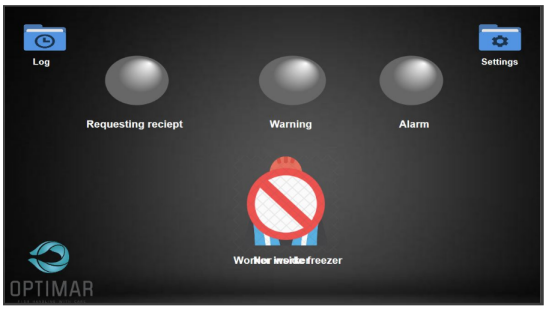


Figure 38: HMI Characteristics

7.1.1.1 Design one

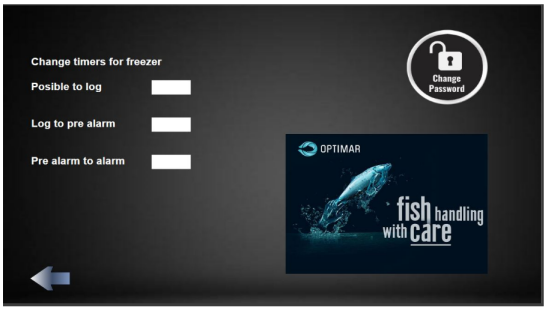
User panel freezer entrance

The GUI has a huge display of Optimar's logo. Easy access to the alarm log, the settings menu and a log in button for workers checking in to freezer.



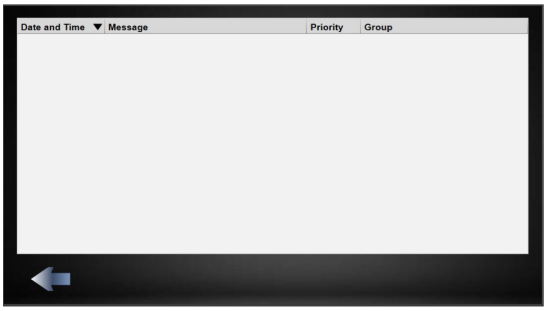
Operation Panel bridge

Easy access to the alarm log and the settings menu. The lights will turn either green, yellow or red to signalize the operations. In the middle of the screen a worker icon or a stop icon will signalize if freezer is manned



Admin page

Admin page that can be accessed from freezer entrance or bridge. At admin page one can change different timers regarding alarm and change password. The admin page is passwordprotected

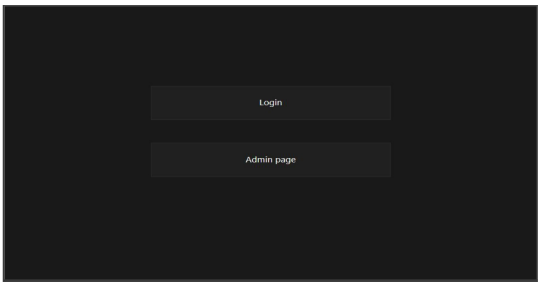


Alarm log

The alarm log can be accessed from the freezer entrance and bridge. This page should show alarm, warnings and log in activity.

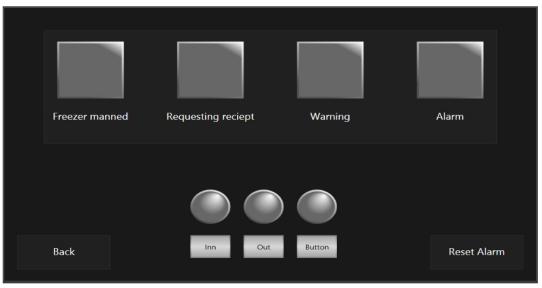
Figure 39: HMI test design 1

7.1.1.2 Design two



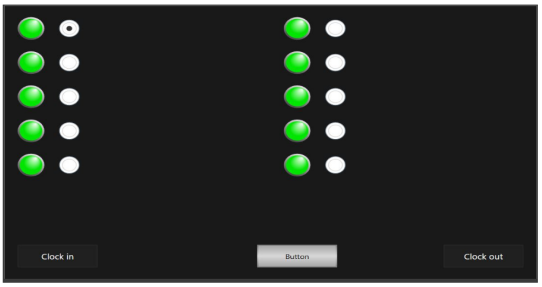
Home page bridge

Access to operation panel (Login) or password protected admin page



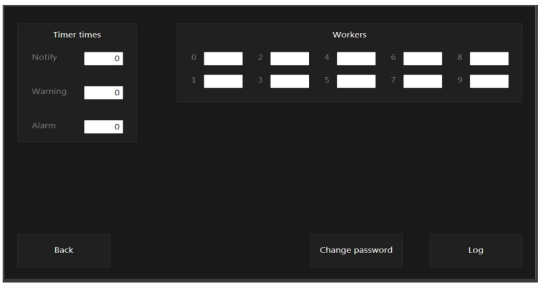
Operation Panel bridge

Main used screen at bridge. Displaying alarm, warning and if freezer is manned. Possibility to reset alarm



User panel freezer entrance

Possibility to have name and check in. Light turns red when checked in.



Admin page

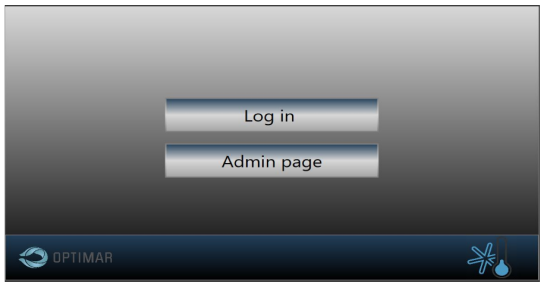
Admin page that can be accessed from freezer entrance or bridge. At admin page one can change different timers regarding alarm and change password. The admin page is passwordprotected

Alarm log

The alarm log can be accessed from the freezer entrance and bridge. This page should show alarm, warnings and log in activity.

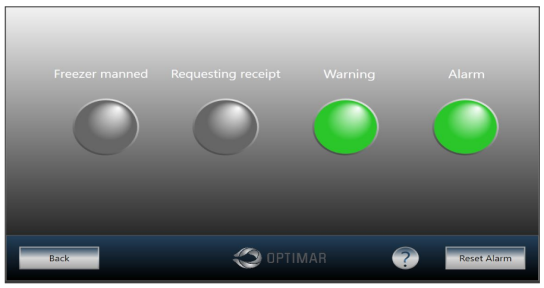
Figure 40: HMI test design 2

7.1.1.3 Design three



Home page bridge

Access to operation panel (Login) or password protected admin page



Operation Panel bridge

Main used screen at bridge. Displaying alarm, warning and if freezer is manned. Possibility to reset alarm

User panel freezer entrance

Possibility to check in and/or out.

Admin page

Admin page that can be accessed from freezer entrance or bridge. At admin page one can change different timers regarding alarm and change password. The admin page is passwordprotected

Help/information button

Pop up window providing information about given page and usage.

Figure 41: HMI test design 3

7.1.1.4 Selected Ideas

This paragraph deals with the selection of elements from each design. In the process of testing all designs on the 7 inch HMI screens, we discovered a need for modification for all three. Creating three different GUIs in the first place gave us three different mindsets on how to create a industrial HMI GUI . All of the different GUI designs have also been reviewed and tested by a nautical student with a former fisherman present. Additionally the GUI was reviewed by the chief programmer Richard Giske.

Chosen ideas and elements from each designs are explained underneath.

- Design one: From the first design we found that notifications, pop up window would be ideal. We find this solution relevant because a pop up window will draw one's attention.
- Design Two: The possibility for workers to come to the screen, tap their name and "Check in" and also "Check out". After some discussion, we came to the conclusion that this will be the easiest form of check in/out at the freezer entrance.
- Design Three: Bar at the bottom of the screen, where important buttons will be placed. Information/help button that is possible to press if the worker is struggling to figure out what to do.

While choosing ideas from each of the designs, several elements were considered. Standards we have mentioned in the chapter "Standards for HMI"[2.9] are one of them. In addition these HMI screens are meant to be placed in a fishing vessel, were several restrictions has to be considered. Key factors for screens on bridge are mentioned below:

- Adjustable screen brightness: To preserve the night vision of workers on bridge
- Dark palette for background: The same reason as mentioned above, and also because the dark palette is more comfortable to operate on. Using a dark background will result in small details appearing brighter, and consequently more visible. This makes up a relatively small portion of the screen and will have less impact on night vision.

The final result is shown in the result chapter [8.3].

7.2 Handheld transmitter and receiver

The communication between the handheld transmitter and the receiver was tested by clicking the buttons on the handheld transmitter and checking if the relays inside the receiver gets triggered. The transmitter and antenna were also put inside the freezer to see if they managed the -30°C

There is also some digital inputs on the receiver, used to activate the buzzer and LED functionalities on the transmitter. After some research, it was discovered that these inputs required an NPN output from the PLC which our PLC did not have. Because of this, relays had to be used to connect the outputs of the PLC to the inputs of the receiver. The digital inputs on the receiver was then tested by activating the outputs on the PLC and check if the buzzer and LEDs was activated on the transmitter.

7.3 Electrical cabinet

Before testing the software and full scale test, all wiring in the electrical cabinet had to be checked. This type of control ensured that there were no short circuits that would damage either HMI, PLC or other components connected inside the cabinet. Such type of testing was performed with multi-meters between different points in the circuits. Finally, power was applied to the system and a voltage level check was also performed.

7.4 Software

For testing the software, the built in simulation in Sysmac studio was used. Sysmac studio can simulate both the PLC and the HMI screen, which made it easier to detect errors and bugs. The simulator is however limited in some cases because it is only capable to simulate one HMI screen at a time, it can not simulate the system menu functionalities and it can also not simulate the SD card functionalities. Which means that real life testing on hardware had to be done.

To make the code as bug-free as possible, the program on the PLC was tested each time the code was edited by using the built-in simulator. All the timers and functions was tested multiple times to try to ensure a pain-less full scale test.

The software has gone through multiple iterations, with each iteration improving the coding style and readability of the code. The code is documented properly with comments, and variables have been given appropriate names.

7.4.1 Communication between PLC and HMI

Testing communication between the PLC and HMI screens were done by editing a global variable on the PLC via the watch-tab function in Sysmac studio, and checking if the variable changed on the HMI screens. The opposite operation was also performed by editing a variable on the HMI screen and checking if the variable changed on the PLC.

7.4.2 SD-CARD

For testing the SD-card functionalities, the built-in function-blocks "WriteFileVar" and "ReadFileVar" was used. These functions-blocks saves and reads variables to/from the SD-card. The testing was done by executing the "WriteFileVar" function-block and checking if the SD-card contained the data. Then the "ReadFileVar" function-block was executed and finally we checked if the PLC had read the data using the watch-tab functionality in Sysmac Studio. The final test was to power off the system and check if all data was stored on the SD-card.

7.5 Prototype

The prototype was tested in a final full scale test, and this full scale test was conducted by testing an average day usage of the safety system. Testing the different types of alarms, messages between HMI's and PLC, between PLC and receiver and between transmitter and receiver.

8 Results

This chapter will show a result of all hours put in to this project. The chapter will be build up by showing the result of various system implemented to build the safety system in it's entirety, and end with an overview picture.

8.1 How the safety system works

The system has two HMI-screens, one outside the freezer room, and another one at the bridge.

The HMI screen outside the freezer allows workers to check in and out of the freezer, and allows for a maximum of two users to be checked in at a time. Once a worker checks in, the timers starts. The worker picks up the handheld transmitter and enters the freezer. After a certain amount of time the handheld transmitter will make a single sound. This sound is the system telling the worker to acknowledge. If the worker ignores this sound and continues the ongoing operation, a warning will be triggered. This will result in the handheld transmitter making more sound. If the warning has not been acknowledged within the given time interval the alarm will be triggered. This will result in the handheld transmitter to activate the LEDs and buzzer, as well as force the alarm to be triggered at the HMI screens. The alarm can either be reset from the bridge or if a false alarm occurs the worker can reset it by pressing both red and green button for three seconds.

When all workers are checked out, the system will reset and turn off it's timers. The HMI screen outside the freezer is equipped with buttons to request for medical help or assistance from another worker. If these buttons is pressed an alert will be displayed on the HMI screen at the bridge.

The HMI screen at the bridge is mainly used to display alerts and alarms. On this screen it is displayed if a worker is inside the freezer and if the warning or alarm is triggered. To reset the alarm from the bridge HMI, a pin code is required. There is also an admin page on this screen that allows you to change the timer values, worker names and the alarm pin code.

8.2 Result due to corona implementations

As mentioned earlier, chapter [3.1], a global pandemic occurred while the group was working on the bachelor thesis. This resulted in the group having to change some of their working habits figure [37].

The school was closed, so the project had to be constructed at home. This made it difficult because of the lack of tools and materials. The workaround was borrowing tools from friends, family and Optimar, although we had to buy some tools. Meetings with supervisors and Optimar had to be done over phone or computer. The changes we had to make did not effect the result of the final product.

8.3 Graphical user interface for HMI

The GUI design, is fine tuned and discussed after many tests, as mentioned in the chapter [7.1.1.4]. Underneath one can read the results of GUI design.

A user manual has been created for both HMI screens, for a deeper explanation of how the screen works. This can be read in attachment [F] and [G]. The manual is made for the user.

8.3.1 Design

We have chosen to have a menu bar at the bottom that follows all the pages of the HMI screens. We used this bar to give the screens a better overview, with a panel to place essential buttons. Essential buttons such as screen brightness, reset alarm, troubleshooter, system menu and information button. One can read in chapter [7.1.1.4] how both nautical personnel and Optimar have impacted the design.

8.3.1.1 Homepage - bridge

The picture below shows the result of the homepage[42]

- Operation Panel
  If you click on "Operation panel", you will enter Operation panel for bridge.
- Admin Page
  If you click on "Admin page", you will enter the Admin Page.
- Troubleshooter
  Will show you the status of the PLC.

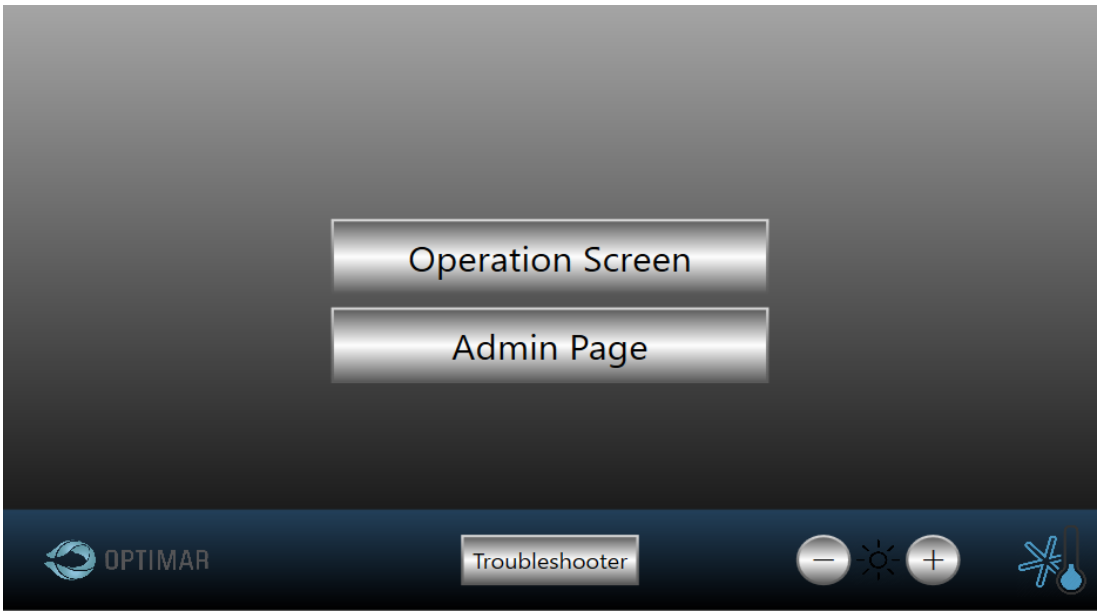


Figure 42: Homepage

8.3.1.2 Operation Panel For Bridge

The operation panel will mostly be used by bridge personnel. The color and appearance are selected to mirror the user. Each light on this page represents an event. In order to give the user a clear overview between each light, we chose to separate each light with rectangles. This page also contains a button that resets the alarm, this operation is password protected.

Figure 43: Operation Panel For Bridge

8.3.1.3 Admin Page

In the admin page end user can change worker names, timer intervals and the pin code used to reset the alarm. One can also access the system menu from the admin page. The system menu is a built-in menu that is used to change settings such as language, user accounts and much more.

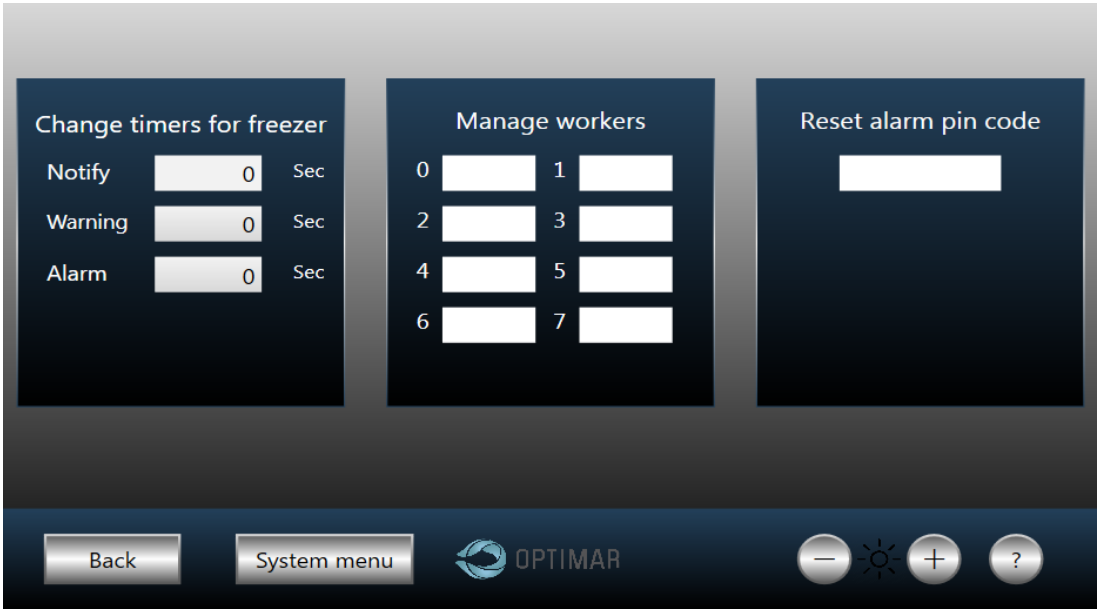


Figure 44: Admin Page

8.3.1.4 Operation Panel for Freezer-room

The user panel for the freezer, displays all worker names. This page allows the worker to select a name, and click the "check in" or "check out" button. The lamp associated with the name will turn green when checked in and grey when checked out. The page has a side panel containing three buttons.

- Medical help
  When this button is pressed a request will be sent to the HMI on the bridge asking for medical assistance.
- Call for workers
  When this button is pressed a request will be sent to the HMI on the bridge asking for help from another worker.
- System menu
  This button will prompt the user for there user credentials, and if the user types the correct user credentials, the system menu will be shown.

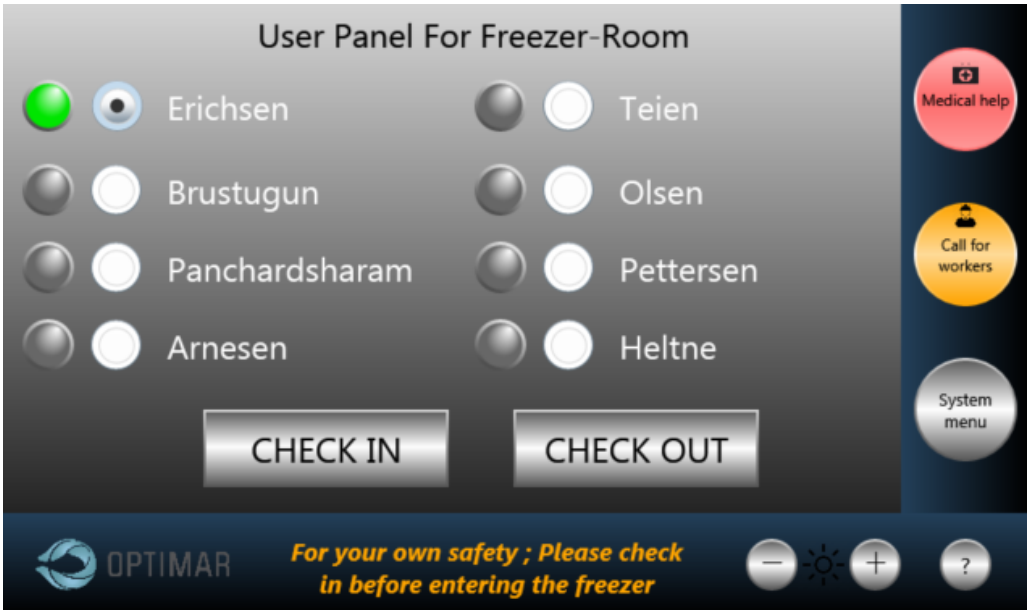


Figure 45: Operation Panel For Freezer-Room

8.4 PLC logic

The PLC consists of two programs running in parallel, the main program and the secondary program. The secondary program will check if any variables is changed by users. These variables are worker names, timer intervals and pin code. If any of these has changed, they will be saved to the SD card.

The main program is described as follows;

i) **First boot**
The main program starts by checking if the PLC recently booted. If that is true it will read saved variables from the SD card. These variables are timer intervals, worker names and pin code.

ii) **User check in**
If the "check in" button is pressed, there is less than two workers already checked in and the alarm is not active, the user will be checked in. After a user has checked in, the name of the user will be stored in an array on the PLC and the timers will start.

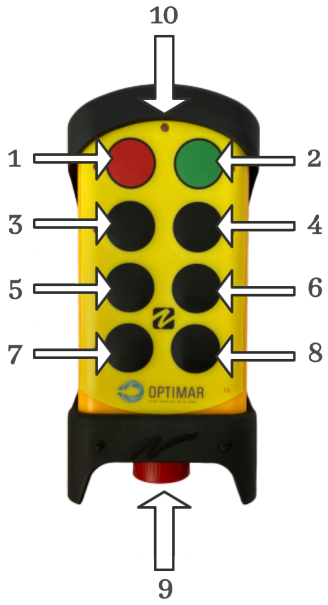
iii) **User checked out**
A user will be checked out when the "check out" button is pressed, the selected user is already checked in and the alarm is not active. After a user has been checked out the name of the user will be removed from the array stored on the PLC, and stop the timers.

iv) **Handheld transmitter**
Check if buttons on the handheld transmitter is pressed. If the acknowledge button has been pressed, it will reset the alarm and warning timer. If the alarm button has been pressed, it will activate the alarm. Assuming that both of the buttons are held in for 3 seconds, it will reset the alarm.

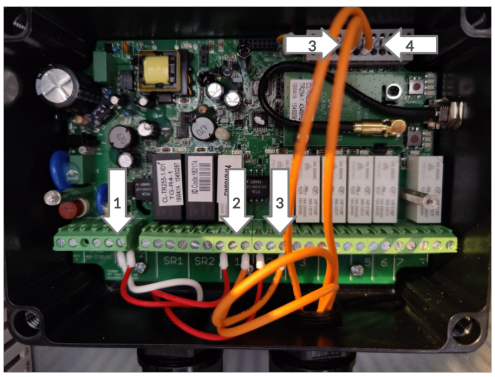
v) **Reset alarm**
At the end it will check if the reset alarm button on the bridge HMI is pressed, if it is pressed and the pin code typed by the user is correct, the alarm will be reset.

8.5 Receiver and handheld transmitter

The receiver and handheld transmitter is programmed to work like an I/O unit. Buttons 1 to 7 on the transmitter will open the corresponding relays on the receiver when pressed. Additionally to this the receiver also uses two inputs. When the first input is active, LED's will start blinking on the transmitter. When the second input is active, the buzzer on the transmitter will activate.



1. Button 1	Red
2. Button 2	Green
3. Button 3	Free for use
4. Button 4	Free for use
5. Button 5	Free for use
6. Button 6	Free for use
7. Left start button	Free for use
8. Right start button	Free for use
9. Stop Button	Stop
10. Top led	Battery Indicator



1. Input power	24V DC
2. Relay 1	Red button
3. Relay 2	Green button
4. Input 36	Buzzer control
5. Input 38	Light control

8.6 Prototype

(a) Front cabinet

(b) Inside cabinet

(a) Backside of the cabinet door

(b) HMI screen bridge

Figure 48: Underside of the cabinet

9 Discussion

A brief overview of results that we have achieved and our experiences in relation to the project. Our experiences in relation to the project and a description of usages.

9.1 Software

The software was written using structured text. The reasoning behind using structured text instead of ladder was that the group already had experience using structured text from past projects. Using structured text also gave us a better overview of the code.

A complication regarding software was the lack of version control in Sysmac studio. Without the "teams" version of the program, there was no way of using any version controls such as git. The work around was as mentioned earlier, to program the PLC based on functions, function blocks and programs working in parallel.

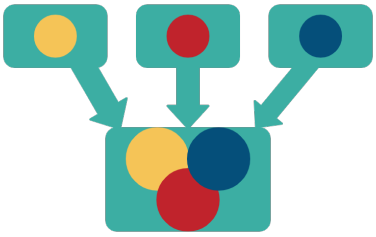


Figure 49: Merge

Another obstacle that we have encountered was the built in simulator in sysmac studio. The simulator worked fine for simple testing, but it could only simulate one HMI screen at a time. The simulator could also not simulate the SD card storage, which was critical to our design. The limitation of the simulator meant that we had to wait for the components to arrive before we could test our program properly.

One of the problems we encountered when writing the software was the process of writing struct data-types to the SD card. The problem occurred because one of the variables that needed to be saved to the SD card was originally using the struct datatype. The problem was not fully resolved, but the workaround was to use the array datatype instead. This resulted in a small redesign of the code and made the code a little worse when it comes to readability.

When we first got our hands on the transmitter and receiver from Tele-radio, the components had already been programmed in a way that would not work with our system. To make the components work with our design, a complete redesign of the code on the PLC had to be made. The reasoning behind this complication was bad communication between us, Optimar and Tele-radio. To resolve this problem we had to contact Tele-radio and ask them to create a new program that satisfied our needs. Tele-radios way of programming the transmitter was private, and therefore only accessible for engineers at Tele-Radio. Unfortunately this lead to an increased cost of the final prototype.

9.2 Hardware

When conducting research on how to wire the receiver to the PLC we discovered that the digital inputs on the receiver requires a zero voltage signal from the PLC. This is something that our PLC was incapable of supplying. We decided that using two relays was the easiest and quickest way to resolve the issue.

After some research we learned that the receiver does support modbus. Modbus communication would resolve the issue mentioned above, but the deadline for the project was right around the corner so this was not implemented.

9.3 Further Improvements and residual work

➥ **HMI-Screen Size**

Since we did not have access to two 7" HMI screens to begin with, we borrowed a 9" HMI screen from a fellow student. This gave us the opportunity to test the system with a slightly larger screen. We see the larger screen as a potential upgrade for our system. People are able to perform certain tasks more quickly on a larger screen.

➥ **Handheld transmitter Size**

The size of the device that we are using, are a bit larger than an ideal size for this type of system. The advantages with a smaller device includes fitting into your pocket and being light weight.

➥ **Handheld transmitter with vibrating functionality**

Vibrating alert is a feature of communications that is used to notify the user of an incoming message. It is primarily used when a user cannot hear a tone. In our case this could be a improvement because the freezer room could be a noisy environment.

➥ **Modbus Communication**

If modbus were implemented, we had managed to operate the system without relays, which would have resulted in less cabling.

➥ **Electrical device to provide cooling**

For control of maximum enclosure temperature.

9.4 Separations from the prototype to a functional product

The differences from the prototype, when it comes to a final product, is:

- External HMI screen would be mounted on the bridge with it's own power supply and with an ethernet cable routed from the cabinet.
- Standard cabling for powering a low voltage system coming from the nearby distribution cabinet.

9.5 Experiences

9.5.1 Planning

In the early stages of the semester, a lot of time was spent on planning the project. The time was spent on having meetings with Optimar, discuss how the system should work, picking out the right components, distribution of tasks and writing a pre-project report. In this case we quickly found the importance of planning ahead and also making a schedule for the whole project essentials.

9.5.2 Distribution of labor

The group had experiences in different fields, making the distribution of labor easy. We utilized all members past experiences and expertise to get the maximum benefits. Even though, all group members had to familiarize themselves with all aspects of the bachelor, but with help from the expertise from each other.

9.5.3 Challenges

There were some challenging circumstances during the work of the thesis. Because of the situation in the community during the ongoing bachelor thesis, there was some delivery delays for several equipment's. Communication between the collaborator Optimar and Tele-radio were somewhat difficult at times. Tele-radio gave us a custom software that did not full-fill our needs, and then needed to be reprogrammed. The reprogramming of the software gave us a delay, leading to extra planning in order to get the system finalized within the given time-frame. Time consuming challenges listed underneath.

- Mounting HMI on electrical cabinet
- Delivery of necessary equipment
- Restrictions due to Covid-19

9.6 Hypothetical profitability

Since Optimar AS has proposed such a system to be designed and implemented in the fishing vessel Geir III in 2020, we assume that such a system is not widespread and not available in the fishing vessel industry.

If the safety system is implemented as a commercial product with the improvements mentioned in the chapter [9.3] the commercial pricing would probably end up at approximately 100.000-200.000NOK.

We believe such a system will help to minimize the outcome of personal injuries in fishing vessel. Injuries in general could be expensive for businesses thus we believe this system could be economically beneficial. Therefore the probability for such a system to be implemented in more than one vessel is reasonable.

9.7 Usage and reflection

This type of safety system can be used to way more than mentioned so far in this thesis. The thesis is a project the group have conducted for Optimar, and is narrowed in on the safety for workers inside freezers at fishing vessels.

In the big picture this system can be slightly modified or not modified at all to service as a broad safety system. The safety system can potentially save lives and minimize the severity of injuries. The system can easily be implemented in production plants, manufacturers and more.

If a worker is working alone and some critical accident happens, it's not as easy as to call the emergency number. If the person is working in an ex-zone they may not be allowed to carry their phones, or other not ex-certified equipment. The simple mechanism for alerting security personnel will then be easier with a ex-certified transmitter consisting of only a few buttons, or if they faint the system will do it automatically.

The worker may work in an area where the noise may be so loud that the sound of an alarm, phone or other units would be drowned in the noise. Noisy work may consist fixing or overhauling one motor or pump in the machine-room, while the other motors are in full operation. In these type of events, the worker could use our safety system to signal an alarm and/or call for help. This can prevent large accidents or fatal injuries to occur.

10 Conclusion

In the final part of the thesis, the report will be rounded off with a conclusion. Initially we mentioned our aims and objectives for the thesis. Finally we have concluded whether these goals have been achieved against the specifications of the task.

The task for the bachelor thesis was as follows;

Optimar wants a safety system for freezers on fishing vessels. This system should consist of two HMI screens; one at the freezer entrance and one at the bridge. The worker would have to bring a handheld transmitter into the freezer. This device is used to verify his or her safety, or to trigger the alarm. The alarm should notify personnel at the bridge.

The result of this project, thus appears as the system that is presented in the results chapter. The system was completed and finalized to the extent possible within the given time frame.

After analyzes and assessments, we believe that this system is relevant and important for work areas were accessibility to radio or other workers are low to non existing.

The system has a user friendly GUI, that is suitable for vessel workers. The system has been designed with scalability and versatility in mind, to make it possible for implementation in new vessels or retrofitted in older vessels, without any major modifications. We can thus conclude that the project has achieved its performance goals.

Whether or not the long term goals are achieved after the project is fully finalized depends on the extent to which Optimar would implement this system.The key factor for Optimar would be the cost benefit of manufacturing and selling the safety system. Therefore one can not conclude whether the long term goals have been achieved at this time, but is something that will emerge in the long run.

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Appendices

A Cooperation Agreement

NTNU

Cooperation Agreement

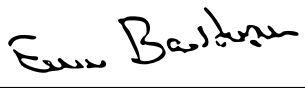
This agreement applies to the following students at the Norwegian University of Science and Technology at Aalesund.

Eilev Brustugun, Daniel Erichsen, Shajeevan Panchardcharam

Commitments

The agreement concerns the groups collaboration on planning, and reporting of the the bachelor project. The bachelor project is held during the last year of the student course of study.

With regard to work and problems within the group, the group have come to the conclusion that the majority decides. If we encounter major disagreements, the group leader will also be able to make the final decision. In addition, the whole group has a collective performance responsibility, so the project can be completed as planned.



Eilev Brustugun

Shajeevan Panchardcharam

Daniel Erichsen

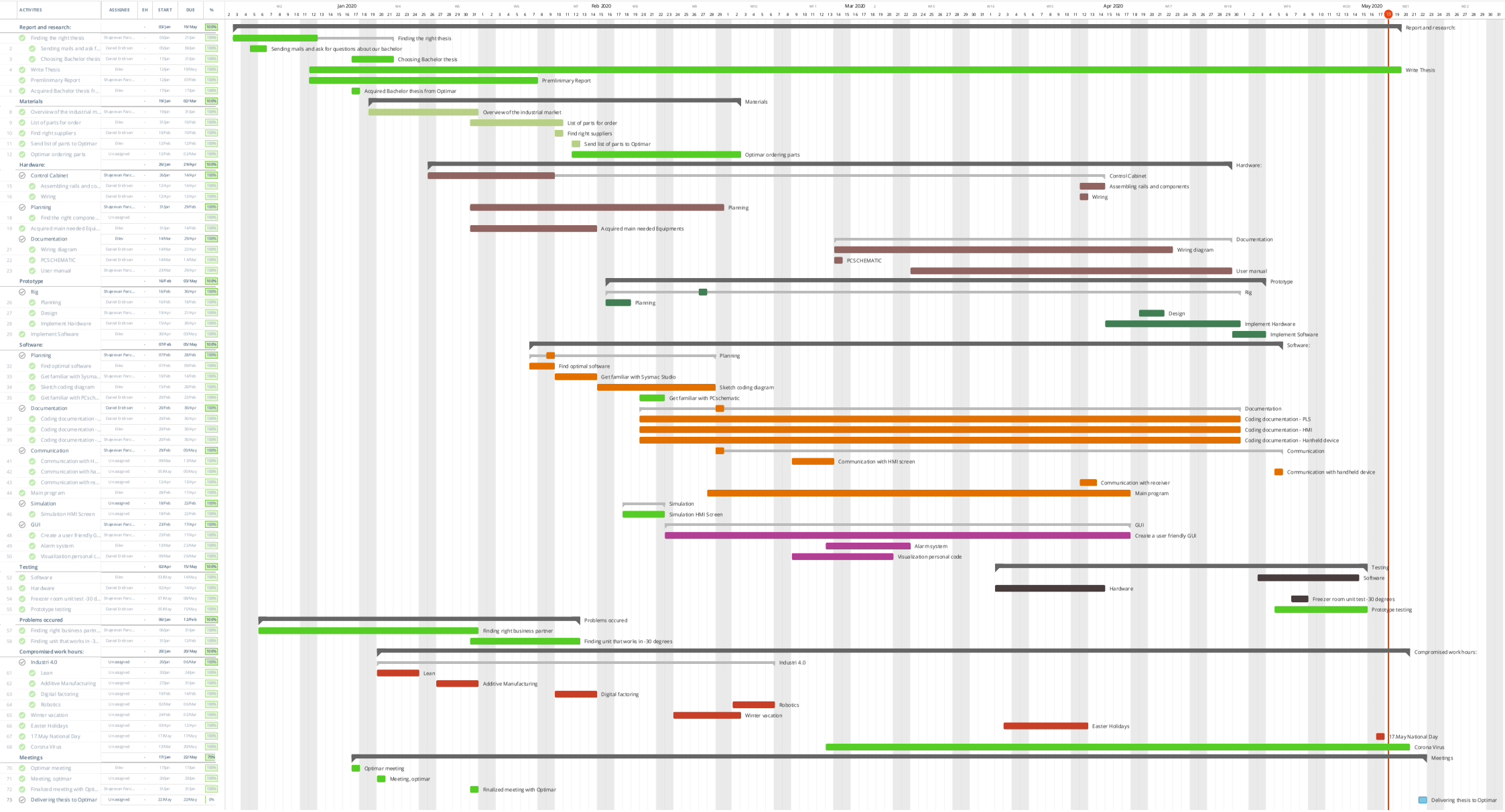
Sted: Ålesund

Dato: 29.01.20

B Progress Schedule

Bachelor 2020

Read-only view, generated on 18 May 2020



	ACTIVITIES	ASSIGNEE	EH	START	DUE	%
	Report and research:		-	03/Jan	19/May	100%
	Finding the right thesis	Shajeevan Panc...	-	03/Jan	21/Jan	100%
2	Sending mails and ask f...	Daniel Eriksen	-	05/Jan	06/Jan	100%
3	Choosing Bachelor thesis	Daniel Eriksen	-	17/Jan	21/Jan	100%
4	Write Thesis	Elev	-	12/Jan	19/May	100%
	Premlinimary Report	Shajeevan Panc...	-	12/Jan	07/Feb	100%
6	Acquired Bachelor thesis fr...	Elev	-	17/Jan	17/Jan	100%
	Materials		-	19/Jan	02/Mar	100%
8	Overview of the industrial m...	Shajeevan Panc...	-	19/Jan	31/Jan	100%
9	List of parts for order	Elev	-	31/Jan	10/Feb	100%
10	Find right suppliers	Daniel Eriksen	-	10/Feb	10/Feb	100%
11	Send list of parts to Optimar	Elev	-	12/Feb	12/Feb	100%
12	Optimar ordering parts	Unassigned	-	12/Feb	02/Mar	100%
	Hardware:		-	26/Jan	29/Apr	100%
	Control Cabinet	Shajeevan Panc...	-	26/Jan	14/Apr	100%
15	Assembling rails and co...	Daniel Eriksen	-	12/Apr	14/Apr	100%
16	Wiring	Daniel Eriksen	-	12/Apr	12/Apr	100%
	Planning	Shajeevan Panc...	-	31/Jan	29/Feb	100%
18	Find the right compone...	Unassigned	-			100%
19	Acquired main needed Equi...	Elev	-	31/Jan	14/Feb	100%
	Documentation	Elev	-	14/Mar	29/Apr	100%
21	Wiring diagram	Daniel Eriksen	-	14/Mar	22/Apr	100%
22	PCSCHEMATIC	Daniel Eriksen	-	14/Mar	14/Mar	100%
23	User manual	Shajeevan Panc...	-	23/Mar	29/Apr	100%
	Prototype		-	16/Feb	03/May	100%
	Rig	Shajeevan Panc...	-	16/Feb	30/Apr	100%
26	Planning	Daniel Eriksen	-	16/Feb	18/Feb	100%
27	Design	Shajeevan Panc...	-	19/Apr	21/Apr	100%
28	Implement Hardware	Daniel Eriksen	-	15/Apr	30/Apr	100%
29	Implement Software	Elev	-	30/Apr	03/May	100%
	Software:		-	07/Feb	05/May	100%
	Planning	Shajeevan Panc...	-	07/Feb	28/Feb	100%
32	Find optimal software	Elev	-	07/Feb	09/Feb	100%
33	Get familiar with Sysma...	Shajeevan Panc...	-	10/Feb	14/Feb	100%
34	Sketch coding diagram	Elev	-	15/Feb	28/Feb	100%
35	Get familiar with PCsch...	Daniel Eriksen	-	20/Feb	22/Feb	100%
	Documentation	Daniel Eriksen	-	20/Feb	30/Apr	100%
37	Coding documentation -...	Daniel Eriksen	-	20/Feb	30/Apr	100%
38	Coding documentation -...	Elev	-	20/Feb	30/Apr	100%
39	Coding documentation -...	Shajeevan Panc...	-	20/Feb	30/Apr	100%
	Communication	Shajeevan Panc...	-	29/Feb	05/May	100%
41	Communication with H...	Unassigned	-	09/Mar	13/Mar	100%
42	Communication with ha...	Unassigned	-	05/May	05/May	100%
43	Communication with re...	Unassigned	-	12/Apr	13/Apr	100%
44	Main program	Elev	-	28/Feb	17/Apr	100%
	Simulation	Unassigned	-	18/Feb	22/Feb	100%
46	Simulation HMI Screen	Unassigned	-	18/Feb	22/Feb	100%
	GUI	Shajeevan Panc...	-	23/Feb	17/Apr	100%
48	Create a user friendly G...	Shajeevan Panc...	-	23/Feb	17/Apr	100%
49	Alarm system	Elev	-	13/Mar	22/Mar	100%
50	Visualization personal c...	Daniel Eriksen	-	09/Mar	20/Mar	100%
	Testing		-	02/Apr	15/May	100%
52	Software	Elev	-	03/May	14/May	100%
53	Hardware	Daniel Eriksen	-	02/Apr	14/Apr	100%
54	Freezer room unit test -30 d...	Shajeevan Panc...	-	07/May	08/May	100%
55	Prototype testing	Daniel Eriksen	-	05/May	15/May	100%
	Problems occured		-	06/Jan	12/Feb	100%
57	Finding right business partn...	Shajeevan Panc...	-	06/Jan	31/Jan	100%
58	Finding unit that works in -3...	Daniel Eriksen	-	31/Jan	12/Feb	100%
	Compromised work hours:		-	20/Jan	20/May	100%
	Industri 4.0	Unassigned	-	20/Jan	06/Mar	100%
61	Lean	Unassigned	-	20/Jan	24/Jan	100%
62	Additive Manufacturing	Unassigned	-	27/Jan	31/Jan	100%
63	Digital factoring	Unassigned	-	10/Feb	14/Feb	100%
64	Robotics	Unassigned	-	02/Mar	06/Mar	100%
65	Winter vacation	Unassigned	-	24/Feb	02/Mar	100%
66	Easter Holidays	Unassigned	-	03/Apr	12/Apr	100%
67	17.May National Day	Unassigned	-	17/May	17/May	100%
68	Corona Virus	Unassigned	-	13/Mar	20/May	100%
	Meetings		-	17/Jan	22/May	75%
70	Optimar meeting	Elev	-	17/Jan	17/Jan	100%
71	Meeting, optimar	Unassigned	-	20/Jan	20/Jan	100%
72	Finalized meeting with Opti...	Shajeevan Panc...	-	31/Jan	31/Jan	100%
73	Delivering thesis to Optimar	Unassigned	-	22/May	22/May	0%

C PC-Schematics

Safety System freezer1

Skoleversion

Bachelor Thesis for Optimar AS

PCSCHEMATIC Automation

Projekttitel:	**Safety System freezer**	**Sagsnr.:**	**Projektrev.:**	**Side**	**1**
Kunde:	Optimar	DCC:		Målestok	1:1
Sidetitel:	Diagram	Tegningsnr.:	Siderev.:	Forrige s	
Filnavn:	Electrical.rev4	Konstr. (projektør): Erichsen	Sidst udskrevet: 12.05.2020	Næste si	2
Sideref.:		Godk. (dato/init):	Sidst rettet: 12.05.2020	Antal sider ialt:	10

Skoleversion

Safety System freezer

NTNU

OPTIMAR

NTNU
Kunnskap for en bedre verden

Projekttitel:	**Safety System freezer**	**Sagsnr.:**		**Projektrev.:**		**Side**	**3**
Kunde:	Optimar	DCC:				Målestok	1:1
Sidetitel:	Indholdsfortegnelse	Tegningsnr.:		Siderev.:		Forrige s	2
Filnavn:	Electrical.rev4	Konstr. (projektør):	Daniel Erichsen	Sidst udskrevet:	12.05.2020	Næste si	5
Sideref.:		Godk. (dato/init):		Sidst rettet:	12.05.2020	Antal sider ialt:	10

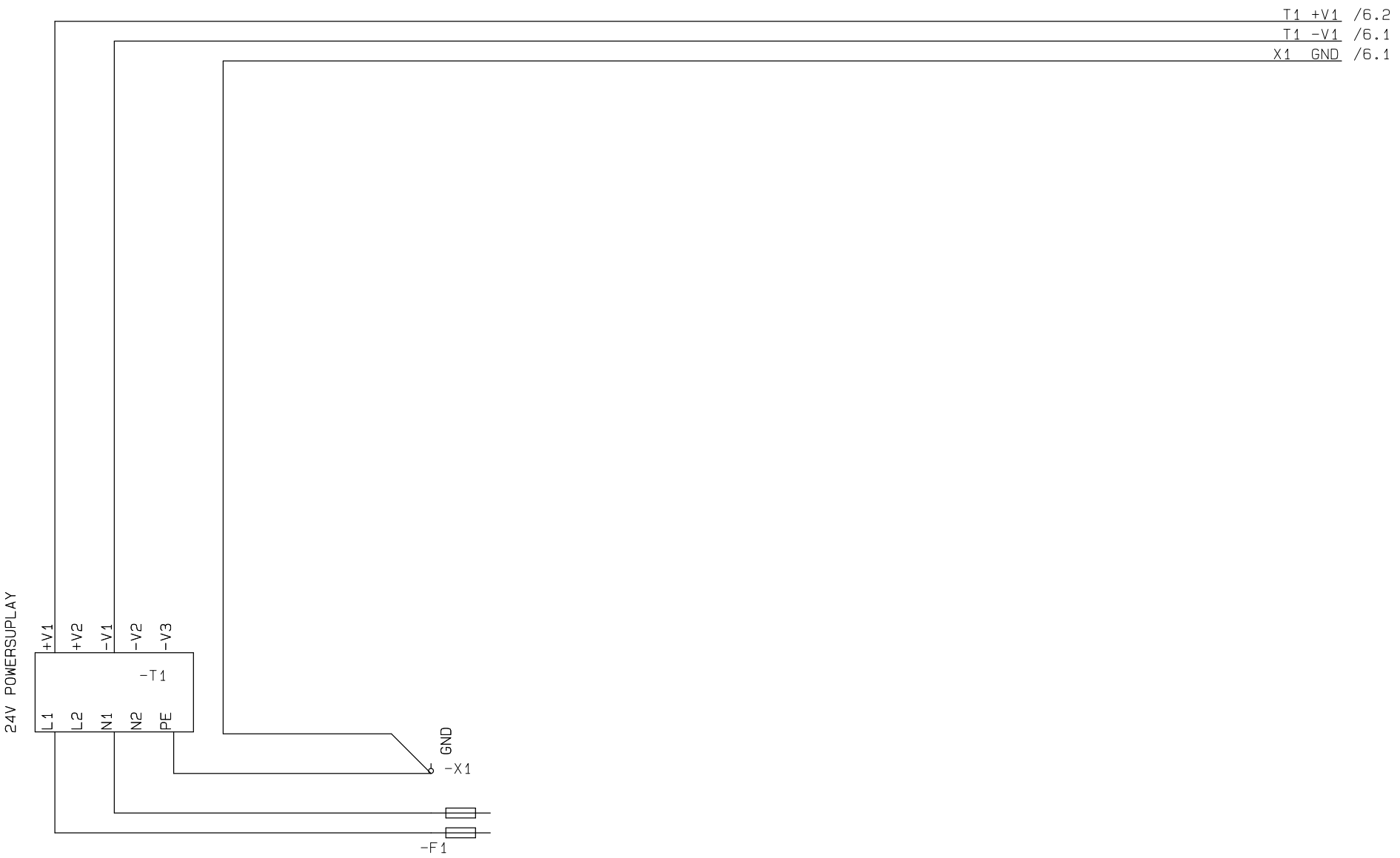
NTNU

Skoleversion

Diagram

NTNU

Skoleversion



PCSCHEMATIC Automation

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Sidetitel:	Diagram	Tegningsnr.:	Siderev.:	Forrige s	3
Filnavn:	Electrical.rev4	Konstr. (projektør):	Erichsen	Sidst udskrevet: 12.05.2020	Næste si 6
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OPTIMAR

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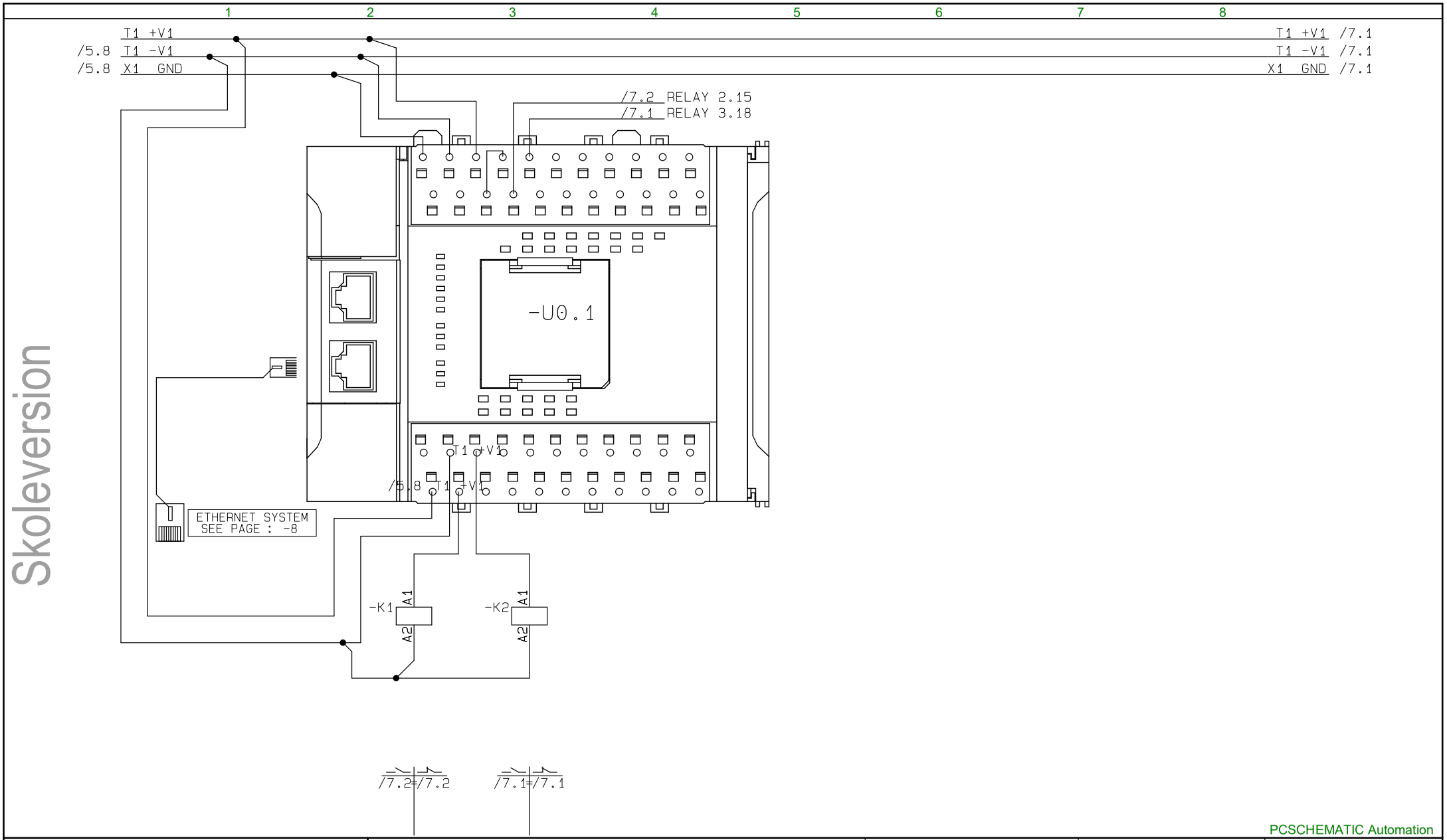
Kunnskap for en bedre verden



Skoleversion

PCSCHEMATIC Automation

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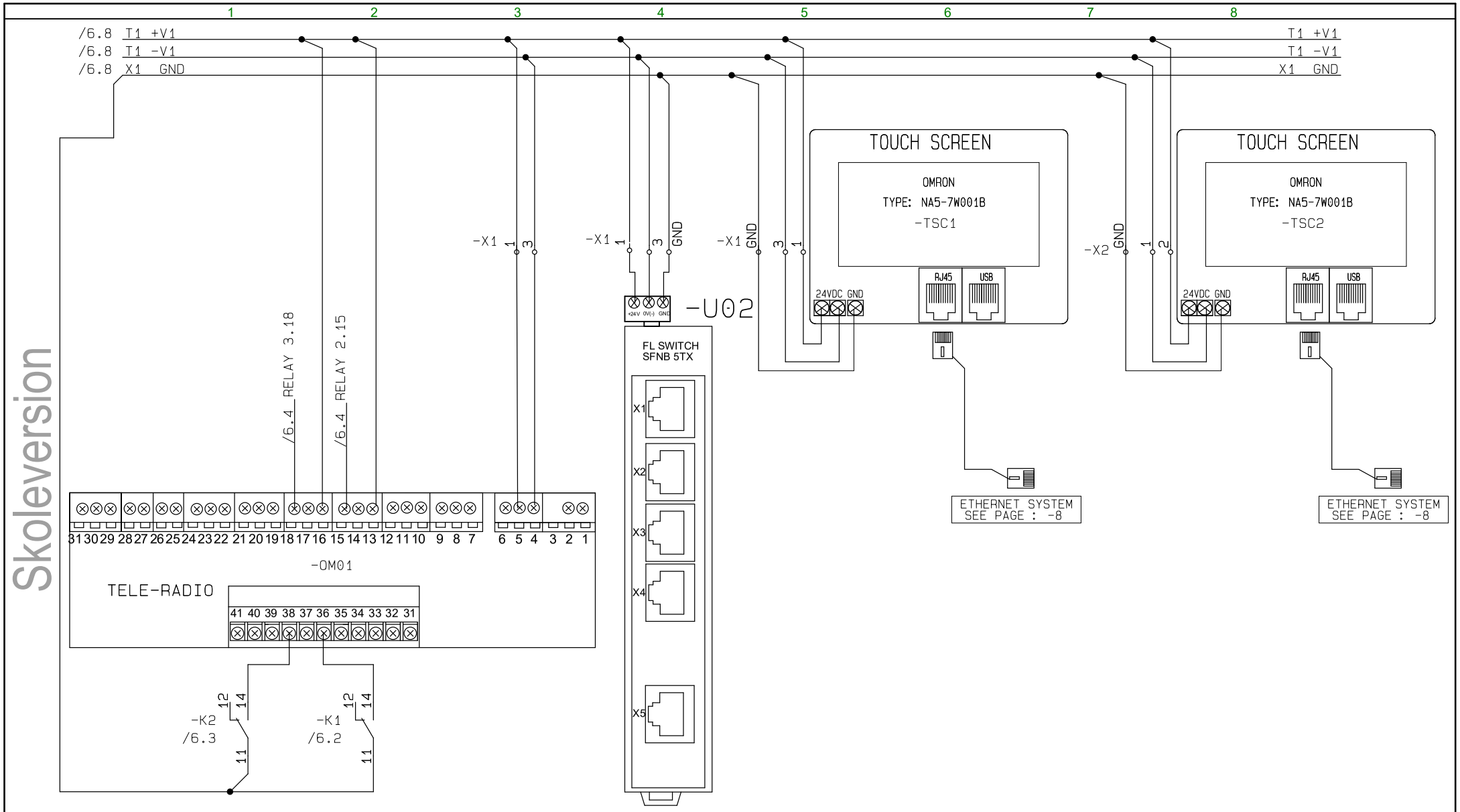
Kunde:	Optimar	DCC:		Målestok	1:1
Sidetitel:	Diagram	Tegningsnr.:	Siderev.:	Forrige s	5
Filnavn:	Electrical.rev4	Konstr. (projektør):	Erichsen	Sidst udskrevet: 12.05.2020	Næste si 7
Sideref.:		Godk. (dato/init):		Sidst rettet: 12.05.2020	Antal sider ialt: 10

OPTIMAR

NTNU
Kunnskap for en bedre verden



PCSCHEMATIC Automation

Projekttitel:	**Safety System freezer**	**Sagsnr.:**	**Projektrev.:**	**Side**	**7**
Kunde:	Optimar	DCC:		Målestok	1:1
Sidetitel:	Diagram	Tegningsnr.:	Siderev.:	Forrige s	6
Filnavn:	Electrical.rev4	Konstr. (projektør):	Erichsen	Sidst udskrevet: 12.05.2020	Næste si 8
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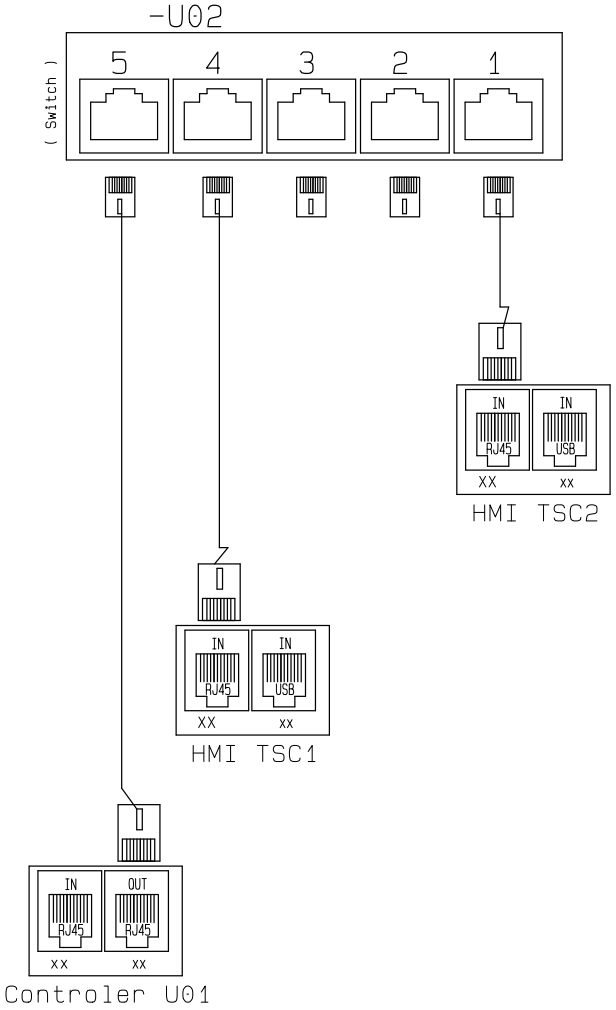

Skoleversion

PCSCHEMATIC Automation

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Kunde:	Optimar	DCC:		Målestok	1:1
Sidetitel:	Diagram	Tegningsnr.:	Siderev.:	Forrige s	7
Filnavn:	Electrical.rev4	Konstr. (projektør):	Erichsen	Sidst udskrevet: 12.05.2020	Næste si 9
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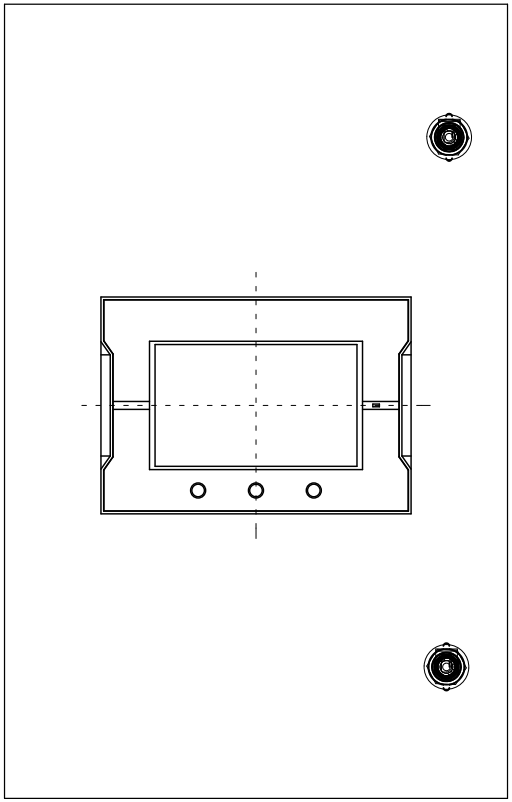
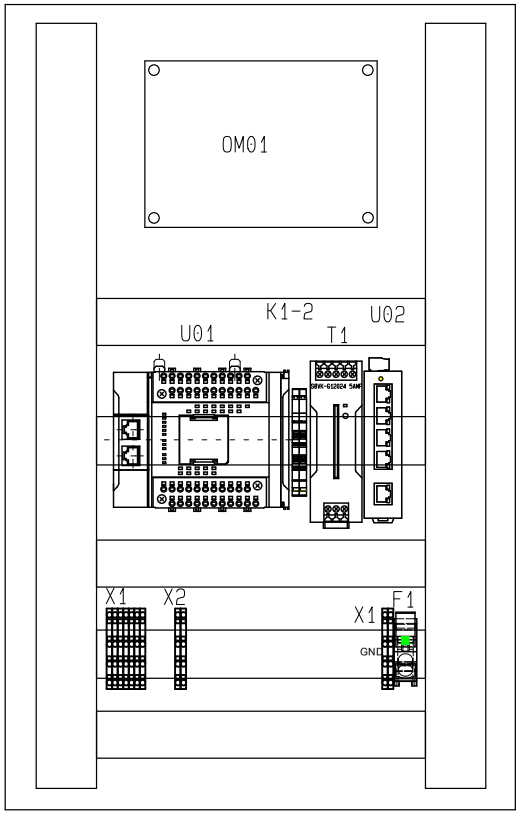
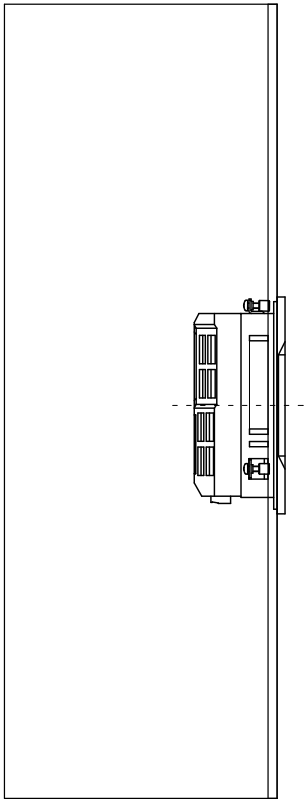
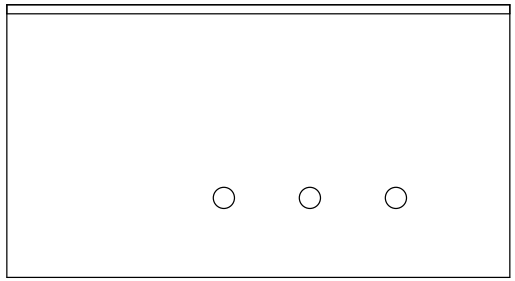
Layout









Skoleversion

PCSCHEMATIC Automation

Projekttitel:	**Safety System freezer**	**Sagsnr.:**	**Projektrev.:**	**Side**	**9**
Kunde:	Optimar	DCC:		Målestok	1:1
Sidetitel:	Diagram	Tegningsnr.:	Siderev.:	Forrige s	8
Filnavn:	Electrical.rev4	Konstr. (projektør):	Erichsen	Sidst udskrevet: 12.05.2020	Næste si
Sideref.:		Godk. (dato/init):		Sidst rettet: 12.05.2020	Antal sider ialt: 10

D Sysmac Studio

NTNU

Source code for
Safety System for workers in freezer room

Bachelor Thesis for Optimar AS

Faculty of Information Technology and Electrical Engineering
Norwegian University of Science and Technology
Norway

09.01.20 - 20.05.20

NTNU

1 Main program

```
//Initialize filewrite functions
frv_0(Execute:=FALSE, FileName:='TimerTimes.csv', ReadVar:=Timers_time);
frv_1(Execute:=FALSE, FileName:='PinCode.txt', ReadVar:=PinCode);
frv_2(Execute:=FALSE, FileName:='Workers.csv', ReadVar:=Workers);

//First run setup
IF P_First_Run THEN
   frv_0(Execute:=TRUE, FileName:='TimerTimes.csv',
       ReadVar:=Timers_time);
   frv_1(Execute:=TRUE, FileName:='PinCode.txt', ReadVar:=PinCode);
   frv_2(Execute:=TRUE, FileName:='Workers.csv', ReadVar:=Workers.Names);
END_IF;

//Handles handheld transmitter click events
chkBtn(btn0:=NOT(BI_redButton),btn1:=NOT(BI_greenButton));

IF NOT(Alarm) THEN
   //Handle check in/out click events
   CheckClockInOut();

   //Initialize timers
   NotifyTimer(IN:=WorkersInside > 0 AND NOT(PinCode = PinCode_1) AND
       NOT(chkBtn.b1 AND NotifyTimer.Q), PT:= SecToTime(Timers_time[0]));
   WarningTimer(IN:= Notify AND NOT(PinCode = PinCode_1), PT :=
       SecToTime(Timers_time[1]));
   AlarmTimer(IN:= Warning AND NOT(PinCode = PinCode_1), PT :=
       SecToTime(Timers_time[2]));

   //Warnings and alarms
   Notify := (Notify OR NotifyTimer.Q) AND WorkersInside > 0;
   Warning := (Warning OR WarningTimer.Q) AND WorkersInside > 0;
   Alarm := Alarm OR AlarmTimer.Q;

   //Manage buzzer and led
   BuzzerTimer(IN:=Notify, PT:=t#4s);
   BuzzerTimer2(IN:=Warning, PT:=t#10s);
   BO_buzzer := (NOT(BuzzerTimer.Q) AND Notify) OR (NOT(BuzzerTimer2.Q)
       AND Warning);

   //Acknowledge button pressed on the handheld transmitter
   Notify := Notify AND NOT(chkBtn.b1);
   Warning := Warning AND NOT(chkBtn.b1);
END_IF;
```

```
//Buzzer should always be active when alarm is true
BO_buzzer := Alarm OR BO_buzzer;
//LEDs should always blink when warning is true or alarm is true
BO_led := Alarm OR Warning OR Notify;

//Alarm button pressed on handheld transmitter
Alarm := Alarm OR chkBtn.b0;

//Reset alarm from handheld transmitter
IF chkBtn.b2 THEN
   Alarm := FALSE;
   Warning := FALSE;
   Notify := FALSE;
   BO_buzzer := FALSE;
   BO_led := FALSE;
END_IF;

//Reset alarm if correct pincode is typed
IF PinCode = PinCode_1 THEN
   Alarm := FALSE;
   Notify := FALSE;
   Warning := FALSE;
   PinCode_1 := '';
   BO_buzzer := FALSE;
   BO_led := FALSE;
END_IF;
```

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2 Writing variables to SD-card

This program checks if any of the user editable variables has been changed. If a variable has changed it will be written to the sd card

```
//Init
fwv(Execute:=FALSE, FileName:='', WriteVar:=PinCode, OverWrite:=TRUE);

//If any timervariables has changed, write to sd card
IF NOT(prev_t1 = Timers_time[0] AND prev_t2 = Timers_time[1] AND prev_t3
    = Timers_time[2]) THEN
   fwv(Execute:=TRUE, FileName:='TimerTimes.csv', WriteVar:=Timers_time,
       OverWrite:=TRUE);
END_IF;

//If pincode has changed, write to sd card
IF NOT(EQascii(PinCode, prev_pinCode)) THEN
   fwv(Execute:=TRUE, FileName:='PinCode.txt', WriteVar:=PinCode,
       OverWrite:=TRUE);
END_IF;

//Loop through worker names and check if any item has changed
FOR i:=0 TO 9 DO
   IF NOT(Workers.Names[i] = prev_Workers[i]) THEN
      Workers_change := TRUE;
   END_IF;
END_FOR;

//If any worker name has changed, write to sd card
IF Workers_change THEN
   fwv(Execute:=TRUE, FileName:='Workers.csv', WriteVar:=Workers,
       OverWrite:=TRUE);
   Workers_change := FALSE;
END_IF;

i:=0;
prev_Workers := Workers.Names;
prev_t1 := Timers_time[0];
prev_t2 := Timers_time[1];
prev_t3 := Timers_time[2];
prev_pinCode := PinCode;
}
```

E QuickGuide

OPTIMAR

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FOLLOW THESE STEPS:

1 LOCATE YOUR NAME

Locate your name and check off the associated circle.

2 CHECK IN

Click CHECK IN and the indicator next to your name will turn green

3 HANDHELD DEVICE

Pick up a device

4 CHECK OUT

Click on your name, hit the CHECK OUT button, put the device back in its place

FOR MORE INFORMATION

READ THE USER MANUAL

F User Manual- Bridge

NTNU

User Manual
HMI - Bridge

Emergency system for workers in freezer room

Presented by:
Norwegian University of Science and Technology

May 11, 2020

OPTIMAR

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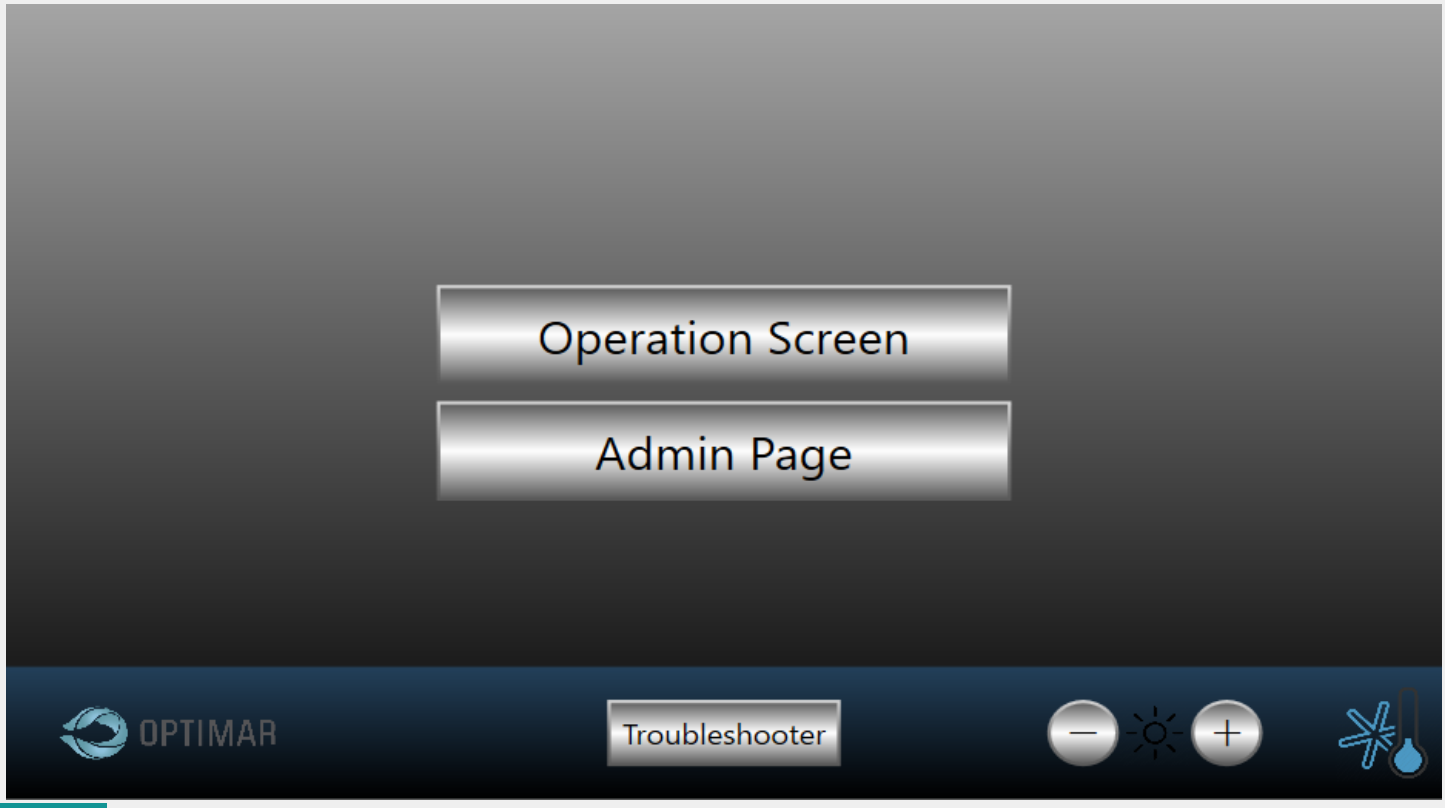
Homepage

OPTIMAR



Homepage

Explanation of Homepage

- Operation Screen
  When you press operation screen, the screen will go from home screen to operating screen
- Admin page - Secured
  When you press Admin page, the screen will go from home screen to admin page. To access the admin page, you must first enter your username and password due to security. The standard username is "administrator" and the standard password is also "administrator".
- Trouble Shooter
  These settings are used for troubleshooting for the NJ/NX/NY series. Refer to the NA-series Programmable Terminal Hardware User's Manual (Cat. No. V117) for details
- Screen Brightness
  Here you will have the opportunity adjust the screen brightness.

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Operation Panel

OPTIMAR

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Operation Panel

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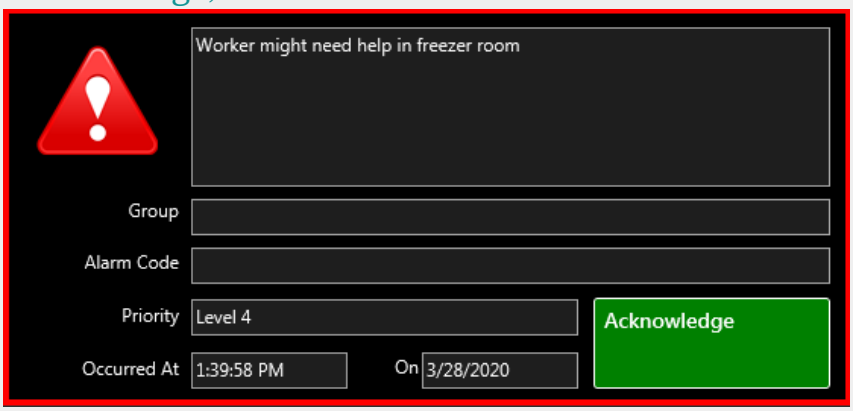
Explanation of the different lamps and their function

- Freezer manned:
  When a worker checks into the freezer room, the "freezer manned" lamp will turn green.
- Requesting receipt:
  When the workers handheld device makes a sound he will have to acknowledge. When the device buzzes, the "requesting receipt" lamp will turn blue.
- Warning:
  When a worker has not acknowledged on the handheld device in a short period of time, the warning light "warning" light will turn yellow
- Alarm:
  If worker still has not acknowledged after a certain amount of time, the "Alarm" lamp will turn red.

Operation panel - Alarm Pop Up

Alarm Pop Up

When the alarm goes off, the window shown below will appear, here you need to press acknowledge, then reset the alarm as shown on the next page.

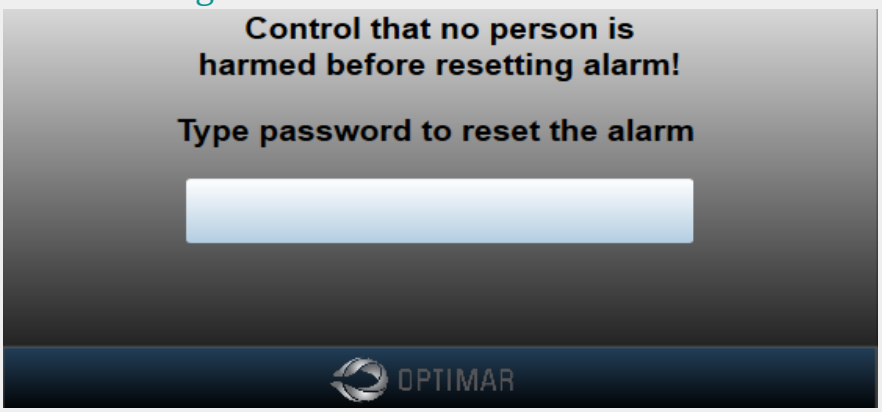


Operation Panel - Reset Alarm

Operation Panel - Reset Alarm

Reset Alarm function

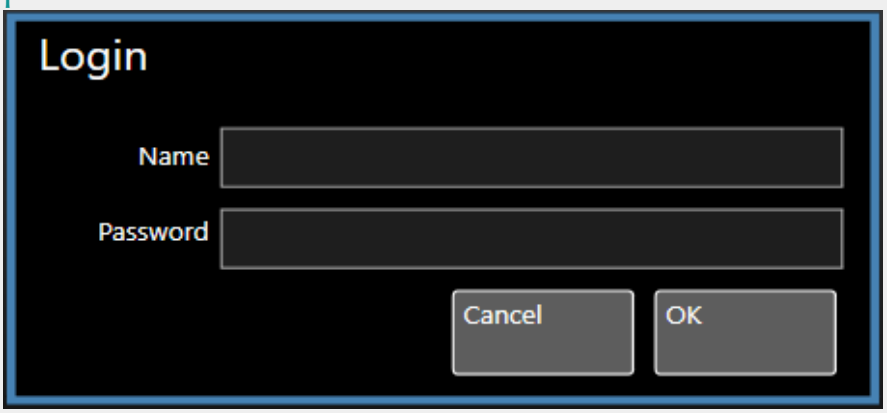
When an alarm is triggered you have the option to silence it and also turn it off when personnel are in safe hand. This is done by pressing the "reset alarm" button and entering a code that is given to the administrator.



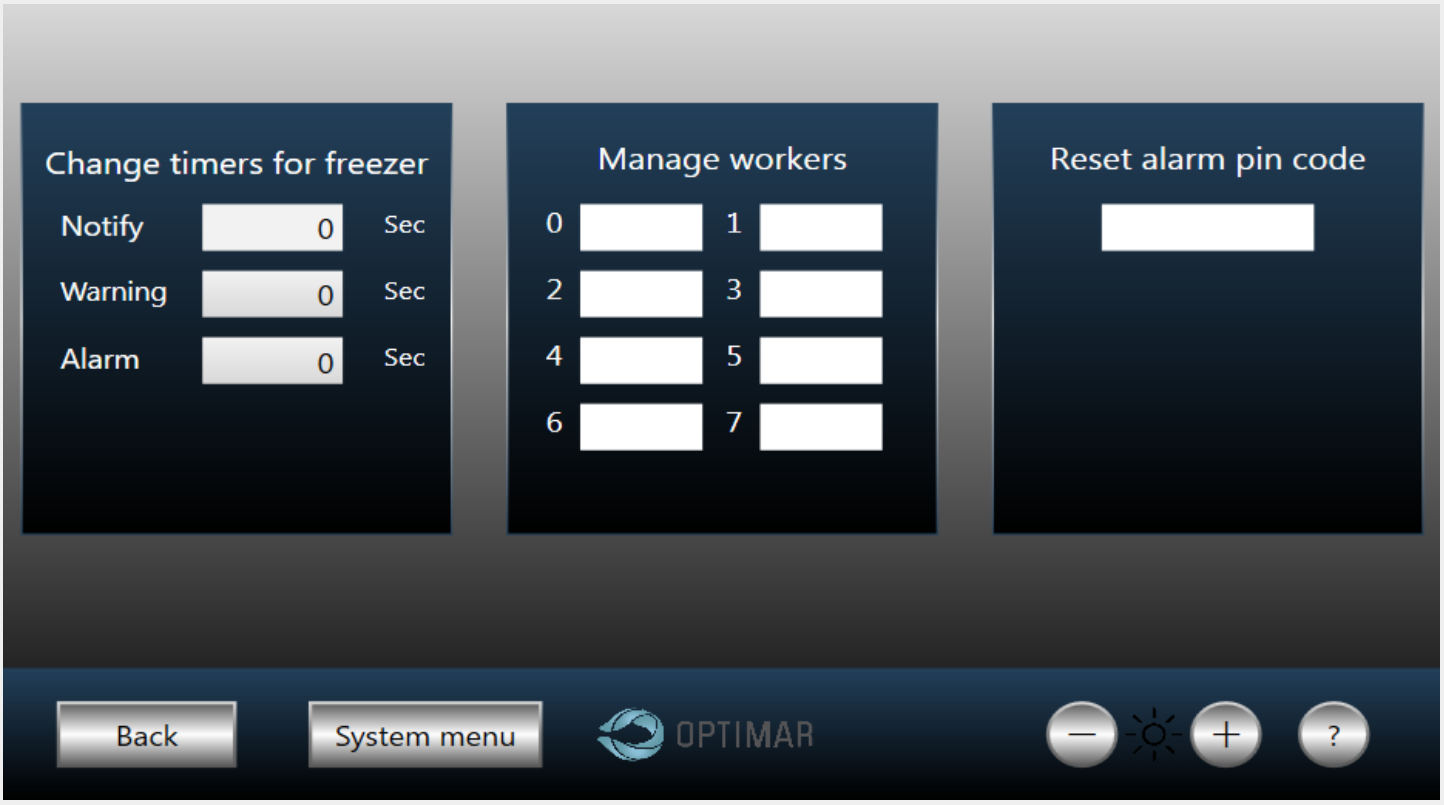
Admin Page - Log In

Admin - Login

To be able to see and manage in the admin page, you will have to type correct username and password.



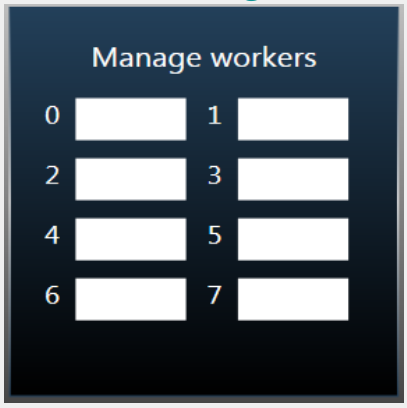
Admin Page


Change timers for freezer
Notify
0
Sec
Warning
0
Sec
Alarm
0
Sec
Manage workers
0
1
2
3
4
5
6
7
Reset alarm pin code
Back
System menu
OPTIMAR
?

Admin Page - Manage Workers

Manage Workers

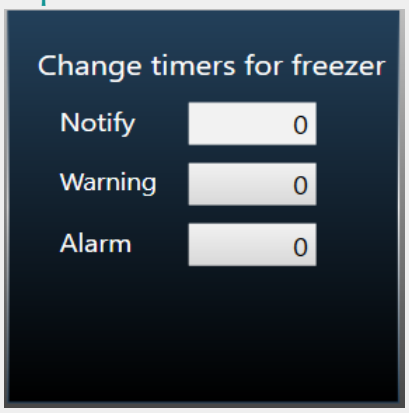
Under manage workers you see that this is numbered from 0 - 7. This means that you have the opportunity to give these 8 names. These will be your workers going into the freezer. You do this by tapping the respective box and naming them.



Admin Page - Change timers for freezer

Change timers for freezer

Under Change timers for freezer, you have the option to set the time interval for when to request a receipt, when to illuminate the warning lamp, and when to trip the alarm. You can change the parameters of each unique worker.



Admin Page - Change password for resetting alarm

Change password for resetting alarm

Change password for resetting alarm gives you the opportunity to change the password that is required when resetting an ongoing alarm. If you click on the white box you will be able to change the password.

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System Menu

OPTIMAR

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System Menu

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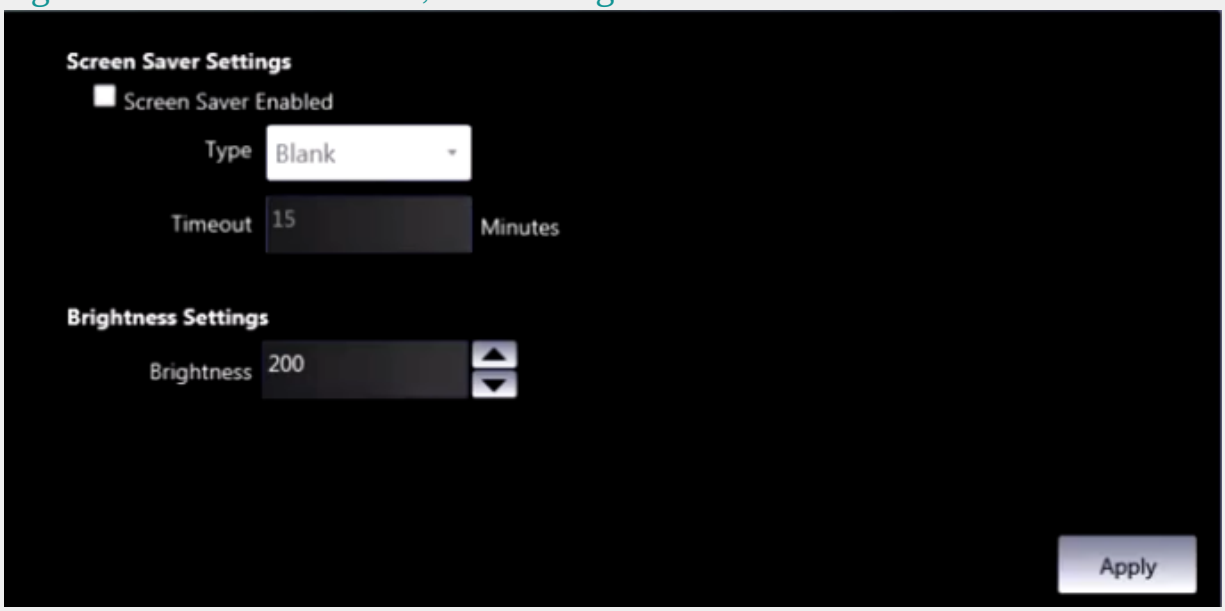
When you press the "System menu" button, the page as shown on the previous page will pop up. Here you have 7 options to choose from.

- Display Settings
- Language Settings
- External Device Settings
- User Accounts
- Alarm Viewer
- Project System Menu Settings
- Device System Menu

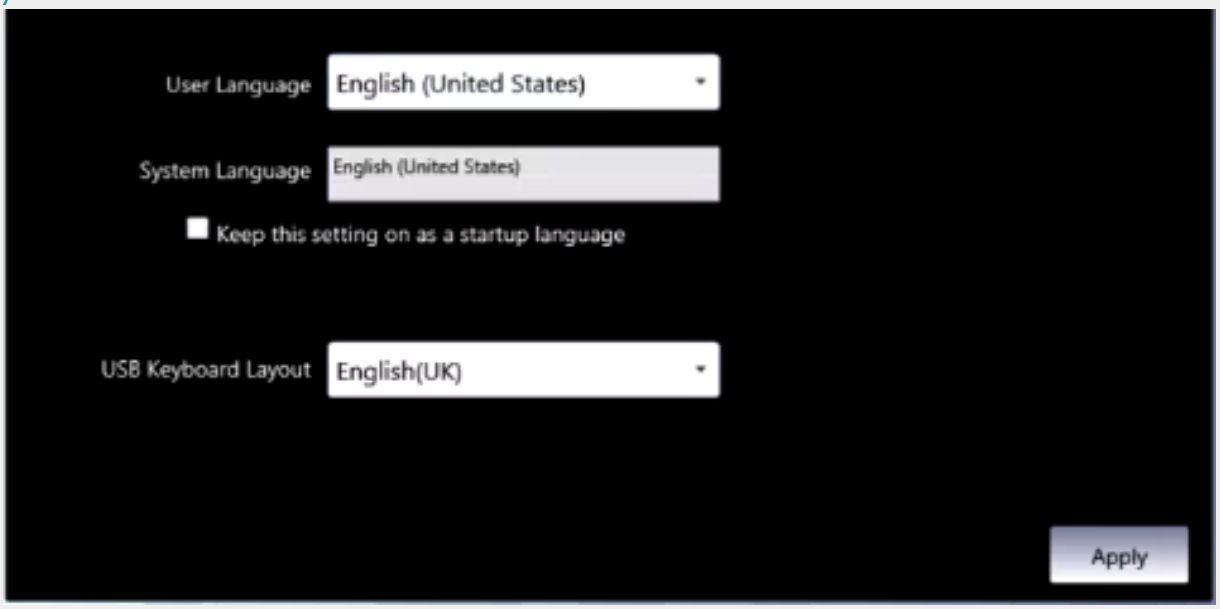
Display settings

Display settings contains: Screen saver, Screen brightness



Language Settings

Language settings contains: System Menu language, User language, System Language, USB Keyboard Layout.



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External Device Settings

OPTIMAR

External Device Settings contains: Communication Driver, Communication Error Indicator,Timeout

User Accounts

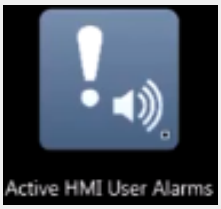
User Accounts contains: User Accounts and Passwords , Add new accounts , Remove accounts

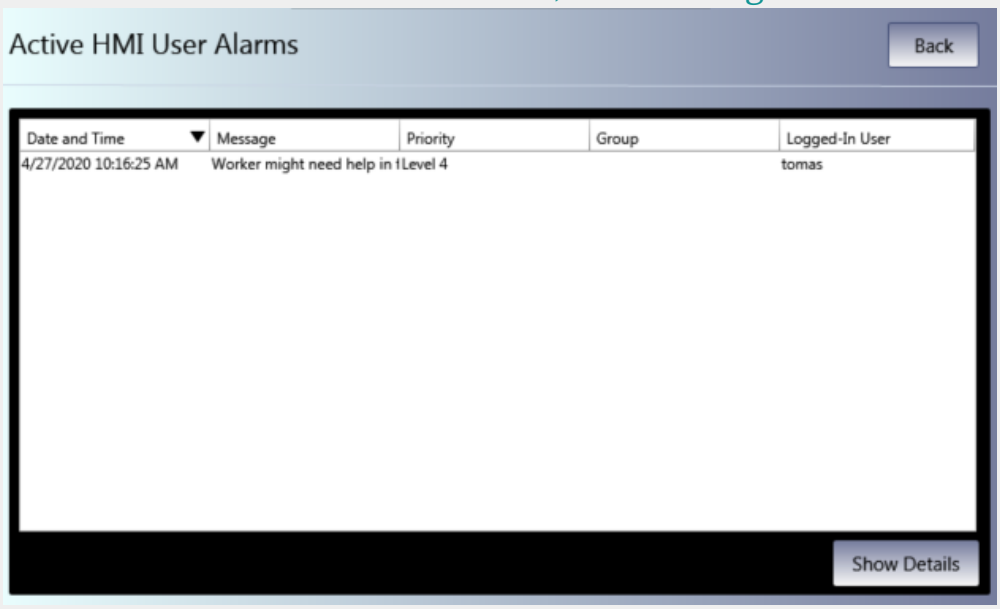
Alarm Viewer

Alarm Viewer contains: View Active Alarms, View Historical Alarms

View Active Alarms

View Active Alarms Contains: View Active Details, Acknowledge Alarms



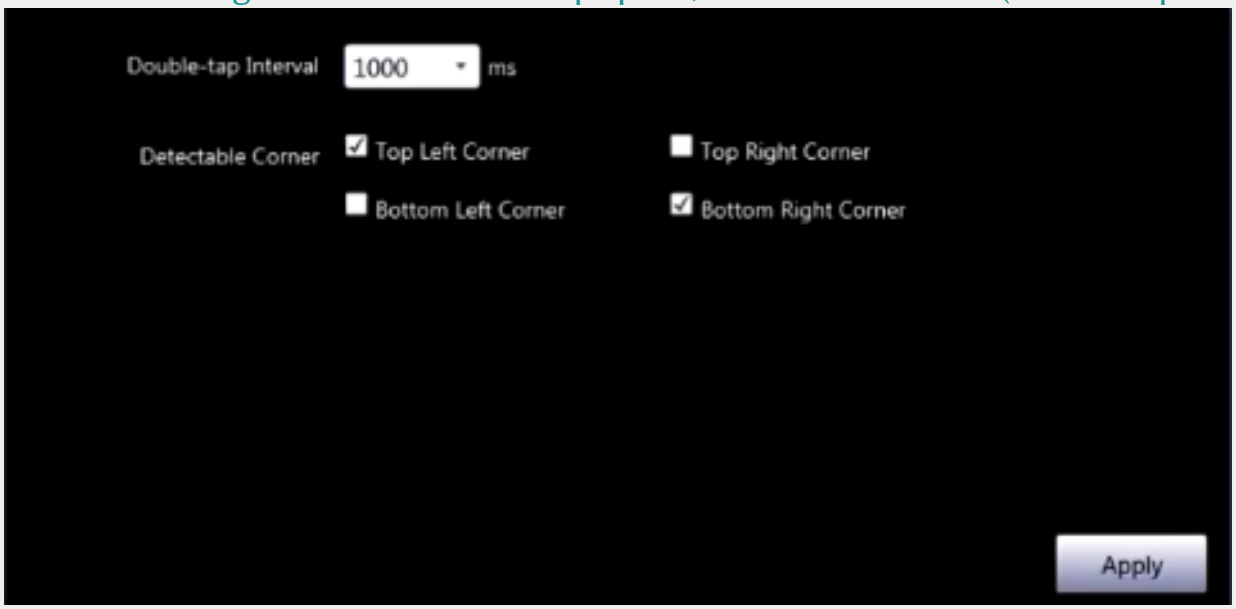


View Historical Alarms

View Historical Alarms contains: Export Alarms, Clear Alarm Log

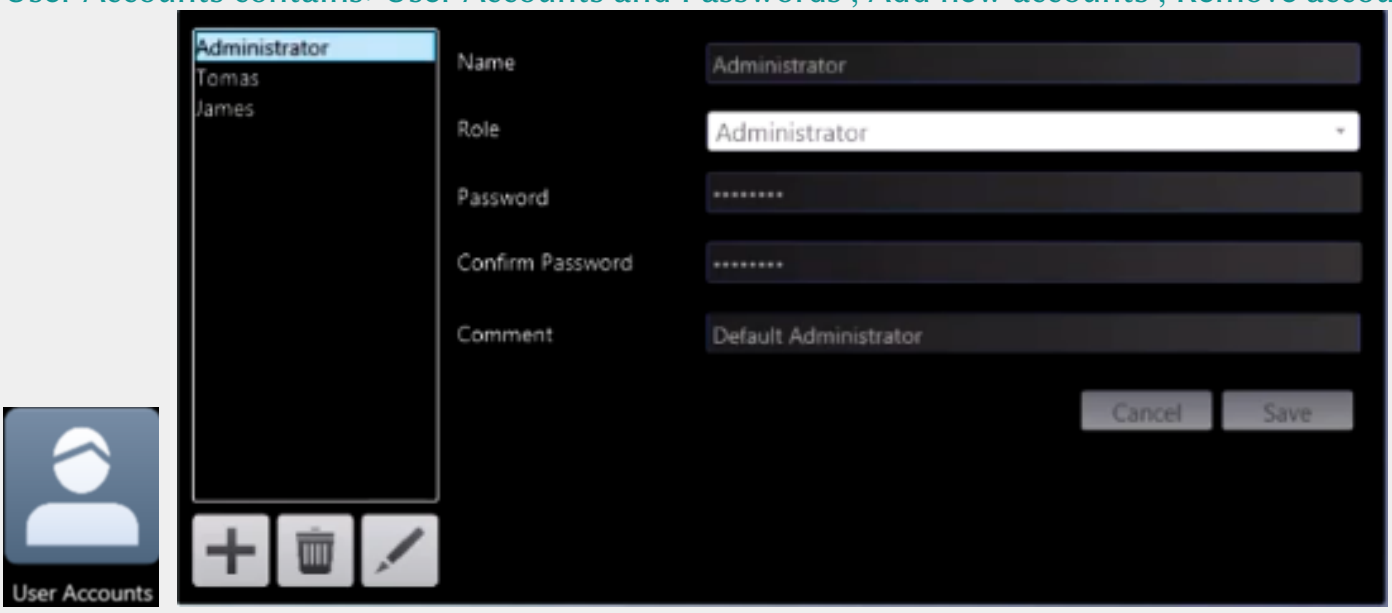
Project System Menu Settings

Project System Menu Settings contains: Double tap speed, Detectable Corner (default top left)



Device System Menu

User Accounts contains: User Accounts and Passwords , Add new accounts , Remove accounts



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G User Manual - Freezer room

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User Manual
HMI - User Panel For Freezer Room

Emergency system for workers in freezer room

Presented by:
Norwegian University of Science and Technology

May 11, 2020

OPTIMAR

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User Panel

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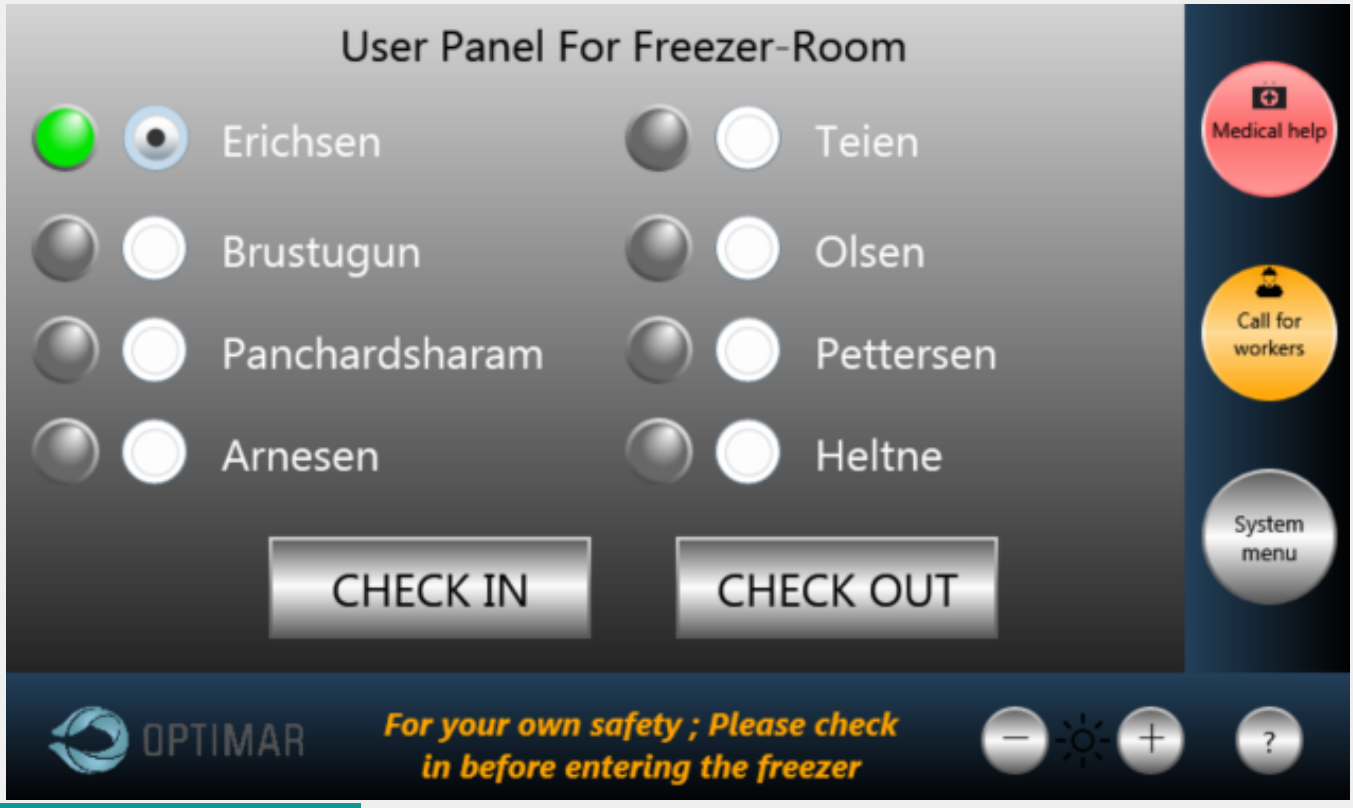

Explanation of User panel for Freezer room

This user manual thoroughly explains how to operate this screen.

- Locate your name
  When you push the button(circle) associated with your name the circle will have a black circle inside it.
- Check In
  When you have pressed on the circle that is associated with your name you can hit the "Check In" button. The lamp next to the circle will turn green.
- Check out
  When the work inside the freezer room is done, click on the circle associated with your name, then click on the "check out" button. The lamp next to your name will turn off.

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Medical Help

OPTIMAR

Explanation of Medical Help

The "Medical help" button allows the worker to send a request to the bridge personnel asking for medical help. An alarm will show on the HMI on the bridge.

Call For Workers

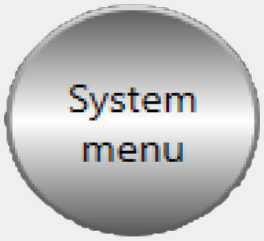
Explanation of Call for workers

The "Call for workers" button gives you the opportunity to request help from another worker. If this button is pushed the bridge personnel will be alerted that personnel is needed in freezer room.

System Menu

Explanation of System Menu

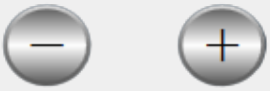
For an explanation of system menu read the User Manual for HMI- Bridge page 15.



Screen brightness

Change Screen Brightness

By pressing the minus button you can decrease the screen brightness, and by pressing the plus sign you can increase the screen brightness.



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H User Manual - Handheld transmitter

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User Manual
Tele Radio - Handheld Transmitter

Emergency system for workers in freezer room

Presented by:
Norwegian University of Science and Technology

May 11, 2020

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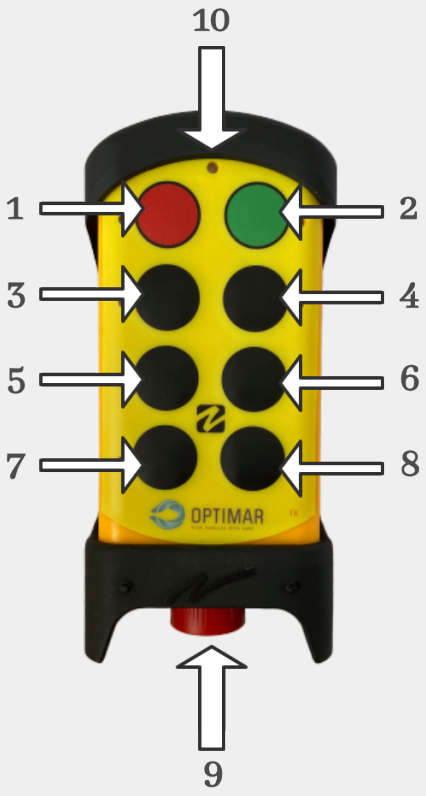

1. Button 1	Red
2. Button 2	Green
3. Button 3	Free for use
4. Button 4	Free for use
5. Button 5	Free for use
6. Button 6	Free for use
7. Left start button	Free for use
8. Right start button	Free for use
9. Stop Button	Stop
10. Top led	Battery Indicator

Tiger G2 Handheld device

This user manual thoroughly explains how to operate the handheld transmitter
To start the device hold button 7 and 8 in together for about 1 second

Acknowledge

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Acknowledge

When a certain amount of time has passed, the handheld transmitter will alert the worker with a singe "buzz". To acknowledge the worker has to push Button 2 - Green.

Alarm

If an accident occurs, you are able to alert the bridge personel by pressing button 1- Red.

False Alarm

If you accidentaly press button 1 -red an alarm will be triggered. You can reset the false alarm by holding button 1-red and button 2-green simultaneously in 3 sec.

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I Component list sent to Optimar

Medlemmer
Shajeevan Panchardcharam
Eilev Brustugun
Daniel Erichsen

Komponentliste

07.02.20

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OMRON

OPTIMAR

Desired units and components

The components listed below are the ones we want to order. The group has gained knowledge up on each component and agreed that these will fit perfectly. Page 2,3 and 4 show some different handheld devices that we think may be ideal, here we are happy to receive tips if you have any experience from any of these.

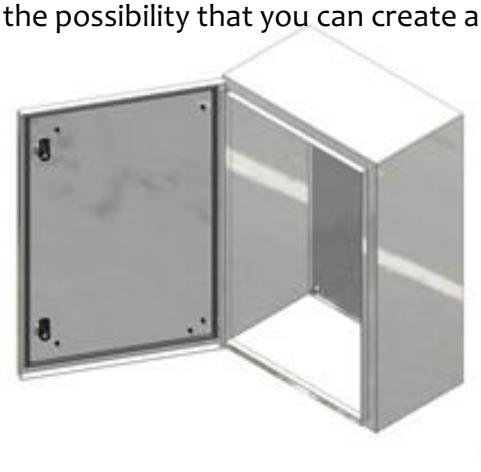
Here are the products from Omron we want to order

Komponent	Produkt nummer	Type betegnelse	Pris per stk	Antall
PLS	672498	NX1P2-9024DT1	7695	1
HMI	392725	NA5-7W001B	14520	2
Ethernet switch	274905	W4S1-05B	3467	1
Strømforsyning	669511	S8VK-S12024	1079	2
UPS	683502	S8BA-24D24D480SBF	2503	1
Batteri til UPS	683501	S8BA-S480L	4985	1
Håndholdt enhet	-	-	-	-

Final sum without cabinet and handheld device: **48 769kr**

Potensiell SKAP :

The link below shows the control cabinet we have looked at: https://www.efa.no/produkt/34680288/veggskap-rustfritt-600x400x300. But we have also thought about the possibility that you can create a cabinet for us.



Medlemmer
Shajeevan Panchardcharam
Eilev Brustugun
Daniel Erichsen

Komponentliste

07.02.20

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Handheld devices that may be potential:

- Tiger G2 med skjerm
- Tiger G2 uten skjerm
- Wearable industrial remote control
- RFsolutions

Tiger G2

(a) Tiger G2

(b) Puma receiver

TECHNICAL SPECIFICATIONS

- Long range
- Ip rating up to IP66
- Battery rechargeable
- Temperature -20 til +55 °C
- Possible remote antenna withstands -30° degrees

Medlemmer
Shajeevan Panchardcharam
Eilev Brustugun
Daniel Erichsen

Komponentliste

07.02.20

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Wearable industrial remote control

(a) Wristband Controller

(b) Radio Receiver-DC4

Technical Specifications

- Equipped with a LED indicator
- Protection rating: IP55
- Watch strap, Lanyard or Belt clip
- 2 way link option
- Operational range 150m, optional up to 300m, High power option
- Operating Storage temperature:- 10 C to + 50 C
- Battery: 3V Lithium battery - rechargeable as standard

Technical Specifications

- Outputs:4 individual relay outputs(10A)
- Inputs: 3 (No operation in default firmware)
- Protection rating: IP65
- Power supply:12V-28V DC supply
- Customisation options: Programmable outputs
- Operating Storage temperature:- 10 C to + 50 C
- Accessories: External antenna

Medlemmer
Shajeevan Panchardcharam
Eilev Brustugun
Daniel Erichsen

07.02.20

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Komponentliste

RFsolutions

Figure 7: Rf-solution unit

TECHNICAL SPECIFICATIONS

- RANGE 2000m
- IP RATING UP TO IP68
- Powered from 3 x AAA Batteries
- Receiver Decoder Operation temperature -10 to +50° Celsius
- Possible remote antenna withstands -30° degrees

J Final cost estimation

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Cost estimation

Faculty of Information Technology and Electrical Engineering

Norwegian University of Science and Technology

Norway

25.03.20

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Product	Quantity	Price
Tiger G2 Transmitter 8 btn IntBat 433MHz	1	4,967.77
Tele-radio Programming kit	1	866.16
Foil Tiger T9-1 Freezeroom Optimar AS	1	350.00
Tiger G2 Receiver 433MHz	1	5,530.02
Antenna High-Flex 5m cable vehicle BNC 433MHz	1	467.90
SSC- Product customization (advanced/features)	1	2,500.00
SSC- Product customization (basic/componentry)	1	1,300.00
Omron NX1P2-9024DT1 controller	1	4,047.00
Omron NA5-7W001B HMI	2	6,379.00,-
Omron S8VK-G12024 Power supply	2	1,005.00
Phoenix contact FL SWITCH SFNB 5TX switch	1	1,032.00
Phoenix contact PLC-BSC-24DC/21 Relay Socket	2	115.00
Phoenix contact REL-MR-24DC/21 Single relay	2	40.00
AE1008.600 Rittal Cabinet	1	3403.00,-
Consumables	x	1,500.00,-
	Total	41,068.85 NOK

Table 1: Cost estimation

K Covid-19 risk analysis

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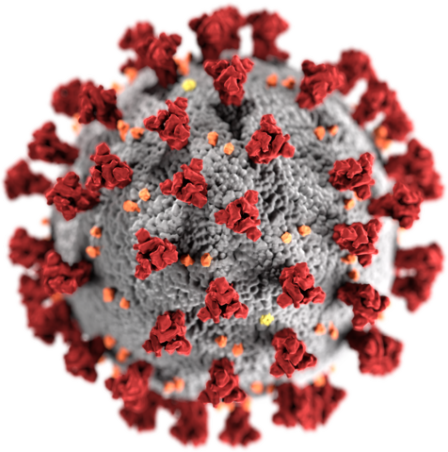
Risk analysis Covid-19



Faculty of Information Technology and Electrical Engineering
Norwegian University of Science and Technology
Norway

25.03.20

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Contents

1 Risk analysis Covid-19

Assessing risk in business or projects that are similar to this, is a continuous process where regular assessments of the danger and problems of the project must be made. This continuous analysis are developing these days because of the Covid 19 also called corona virus becomes a global pandemic.

This document will be a mapping of the risk in connection with the corona virus and how it may affect the groups thesis. The document will take up different aspects that can be a issue and what the plan will to overcome these issues.

Risk table

Risk level	Low 0 - Acceptable Ok to proceed	Medium 1 - Alarm Take mitigation	High 2 - Unacceptable Seek support	Extreme 3 - Intolerable Project on hold

Severity of consequences				
Frequency of incident	Very low	Low	High	Very high
Very often	School closed			
Often	Home quarantine	Workload/ stress	Delayed shipment	
Rarely			Communicat-ion problems Lack of resources	Manufacturer failing to deliver
Very rare				Group member/s getting corona

Table 1: Severity of consequences corona

1.1 Risk measures implemented

This section will take care of the risk measurements taken because of Corona. The main risk measurement can be read in the pre-project in attachments, but here the risk of a pandemic was not high on the list. But today's reality is that the world is facing a pandemic that will effect everyone.

Due to the pandemic the group will be taken some extra security measures to maintain healthy group members and finishing the thesis at the best way possible. The group will follow the Norwegian and the who regulations due to the pandemic. Underneath a picture of the most impotent aspect for every group members hygiene.

Figure 1: Risk measures implemented

Other security measures the group is taking, not including mandated by the government:

- Stay home as much as possible
- Video conference as much as possible
  - Meeting withe the group members
  - Meetings with supervisor
- Focusing on the aspects adding value to the project
- Focusing on the aspects that can bee done before all parts arrive

Risk measures

Problem	Description / Risk mitigation
Delayed shipment Lac of resources	This may accrue due to closed schools and Optimar having trouble with the pandemic. In this times it's important to work with the report and other aspects where we aren't in need of a workshop or other special tools.
Manufacturer failing to deliver	If some of the given parts needed isn't delivered, the group needs to improvise with the equipment available. This can be done by simulation from a computer or so on.
School closed	This is worked around with video conferences with supervisor and working from home.
Workload/stress	Every group member needs to hold a open dialog regarding stress and workload. All group member should have a workload that suits them and there level.
Communication problems	This problems can develop during a pandemic and the work is often done privately. Therefor it's important to attend video conferencing minimum twice a week, and to constantly have a dialog within the group.
Group member/s getting corona	Because this may accrue its important that every group member is updated about everything going on in the project If the workload gets to much it's possible to postpone the thesis, but the group will do everything to avoid any delays.
Home quarantine	In this times it's important to work with the report and other aspects where we aren't in need of a workshop or other special tools. The person in quarantine needs to hold a constant dialog with the rest of the group.

Table 2: Risk measures due to corona

11 Meeting reports

NTNU

Optimar AS

Minutes for January 17, 2020

Present: Åge Martin Molnes, Robert Johnsen, Daniel Erichsen, Shajeevan Panchardcharam, Eilev Brustugun

Agenda

This meeting covered a possible bachelor thesis that Optimar AS presented for the group.

Introduction

Optimar AS is a company that delivers tools and equipment to the boat industry, including freezers. These freezers keeps a temperature of around -30 degrees and the workers stays in this freezer alone for around 20-30 min at a time. Accidents has occurred in these freezer previously, where the workers has not been able to alert the crew members. Because of these accidents occurring, Optimar wants the group to construct an alert system that monitors the personnel entering these freezers.

Plan

Optimar showed the group a drawing of the ship, and presented a rough plan of how the system should work.

- Freezer door has to be monitored
- Worker has to log every time he enters the freezer
- A handheld wireless device that the worker has to take with him inside the freezer. This device is used to log every x amount of time.
- HMI screen on bridge of the boat
- Separate 0V and ground connection
- 24V system
- Charging of the handheld device
- Can be adapted to different boats
- The system needs to be isolated from the other systems on the boat.
- UPS in case of power outage

12 Pre-project

NTNU

Warning/Alert System

Bachelor Thesis for Optimar AS

Daniel Erichsen, Eilev Brustugun, Shajeevan Panchardcharam

A thesis presented for the degree of Bachelor in Automation

NTNU

Faculty of Information Technology and Electrical Engineering
Norwegian University of Science and Technology
Norway

09.01.20 - 20.05.20

NTNU

Preface

This project report marks the beginning of our final bachelor thesis as automation engineering students. The study is conducted at the Faculty of Information Technology and Electrical Engineering at the Norwegian University of Science and Technology.

The report is written and prepared by a group of students consisting of Eilev Brustugun, Daniel Erichsen and Shajeevan Panchardcharam. The assignment was given by the fish handling company Optimar.

Eilev Brustugun

Shajeevan Panchardcharam

Daniel Erichsen

Sted:

Dato:

Abstract

The report deals with the planning and implementation of the project the group will work on during the bachelor's period. It summarizes the students' interpretation of the assignment with the client's wishes and specifications.

Contents

List of Figures

Terminology

PLC - Programmable logic controller

HMI - Human Machine Interface

IP - Internet protocol

UDP - User Datagram Protocol

WIFI - Wireless Fidelity

PC - Personal Computer

USB - Universal Serial Bus

GUI - Graphical User Interface

LED - Light Emitting Diode

IP(rating) - International Protection

UPS - Uninterruptible Power Supply

GIT - Git is a type of control system. It is characterized by being distributed and not directory hierarchy based. An important design criterion for Git was the speed of merging

1 Introduction

1.1 Background

The final semester of the bachelor degree, for automation students at NTNU Aalesund, conducts a major project often given by companies. The purpose of this project is to give the students an introduction to project management in addition to creating an association to the theory that has been applied over the years and to convert the knowledge of theories to practice.

The work of this project is set from mid-january to mid may, and it is calculated that each member of the group gets 500 work hours. After the project are completed and handed in to the supervisor the final grade will be conducted.

The project assignment is an result of a collaboration between Optimar AS and NTNU.

1.2 Collaboration

Fish handling with care is the heart and everything for what Optimar do. Caring for both quality fish handling and our customers' needs has been a key factor in Optimar's 80-years long history. This philosophy has led Optimar to become a strong, competent and preferred supplier. Optimar is a equipment manufacturers working on unique and in-demand expertise in robotics and automation for the fishing and aquaculture industries.

Optimar is located outside of Aalesund, in the heart of the Norwegian maritime and seafood cluster. They are well known for sharing competence and expertice from company to company. This company has approximatley 500 emplyes in Norway, Spain, US and Romania. (https://optimar.no/about)

Figure 1: Oppdragsgivere

2 Project organization

Student	ID NUMBER
Daniel Erichsen	488581
Shajeevan Panchardcharam	488580
Eilev Brustugun	484218

2.1 Assignments for the project group - organization

We will be using Instagant together with Asana in order to keep track of all the assignments for the bachelor thesis. This plan will be updated at a weekly meeting every Tuesday. Each task will be assigned a designated person which is responsible for making sure that the task is done within the deadline. A second member will also be assigned as support to each task.

Name	Role
Daniel Erichsen	Project Manager
Shajeevan Panchardchara	Project Secretary
Eilev Brustugun	Project Engineer

2.2 Assignments for the project manager

The group leader is responsible for everyone doing their assigned tasks, and has an overview of what is being done at any given time.

- Main contact person
- Task manager
- Delegate tasks when necessary
- Responsible for progress

2.3 Assignments for the project secretary

The secretary is responsible for setting up meetings and shall act as contact person if the group leader is not present.

- Secondary contact person
- Responsible for meetings
  - Invitations
  - Meeting report
- Responsible for the main report

2.4 Assignments for all member

Everyone in the group is responsible for completing the task they are assigned. This must be done according to the project plan set by everyone in the group. Every group member is responsible to log their work hours according to plan. Last but not least, it is important that report writing is maintained throughout the project.

- Completing the tasks assigned to them
- Obligated to work on the thesis Mon-Fri 9-15
  - Se section 4.0 for details
- Log every work hour at the end of each week
  - Se section 4.0 for details

3 Project participants

3.1 Supervisors

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Mail: kjell.i.tomren@ntnu.no

Professor at NTNU

Department of ICT and science

Ottar Osen

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First associate professor, Automation technology

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Åge Martin Molsnes

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Automation Team Manager

Optimar AS

Robert Johnsen

Mobile: +47 91 13 32 31

mail: rjo@optimar.no

Senior Automation Engineer

Optimar AS

3.2 Group Members

Daniel Erichsen
Age : 25 år
Tlf : +47 41 64 33 95
E-mail : danieeri@stud.ntnu.no
CV : Attachment I.1

Earlier expertise

From earlier i have technical letters in automation systems and also worked as an electrician before starting the course to get the bachelor in automation.
Through my time as an student at NTNU Aalesund i have acquired relevant experience and skills within:

- Report writing in Latex
- Programming of Java, Matlab/simulink, Arduino and PLC
- Group projects

This all beside the given lectures taken through the course

Specialized in the subjects

- Mathematics 3
- Intelligent systems
- Real time programming

Motivation and expectations

The motivation of the bachelor comes from the great chemistry and the hard work mentality in the group. I expect them to deliver at there best, and aiming for the best achievable grade as i do my self.

Eilev brustugun
Age : 24 år
Tlf : +47 958 75 903
E-mail : eilevb@stud.ntnu.no
CV : Attachment **??**

Earlier expertise

From earlier i have technical letters in "dataelektronikk" and also worked as an IT technician before starting the course to get the bachelor in automation.
Through my time as an student at NTNU Aalesund i have acquired relevant experience and skills within:

- Report writing in Latex
- Programming of Java, Matlab/simulink, Arduino and PLC
- Group projects

This all beside the given lectures taken through the course

Specialized in the subjects

- Mathematics 3
- Intelligent systems
- Real time programming

Motivation and expectations

I am motivated to work as much as possible to finish the bachelor with the best grade possible. I expect my self and the rest of the group perform to the best of their abilities.

Shajeevan Panchardcharam
Age : 23 år
Tlf : +47 917 45 423
E-mail : shajeevp@stud.ntnu.no
CV : Attachment J.1

Earlier expertise

Studied science at Valler high school, Through the course of study at the automation engineering study at NTNU Aalesund, I have acquired several relevant and useful skills for the project. These include

- Report writing in Latex
- Programming of Java, Matlab/simulink, Arduino and PLC
- Group projects

This all beside the given lectures taken through the course

Specialized in the subjects

- Mathematics 3
- Intelligent systems
- Real time programming

Motivation and expectations

I find it exciting that the project is based on a real problem on today's boats. In addition, I think it can be interesting to carry out a formal project work that caters to a customer. This leads to me spending a lot of time on projects

Basically, I want both me and my group to end up with a project-worthy grade A. I have previously experienced that working in groups brings out the best in my profession, while at the same time tending to complement what the others in the group are good at. I see myself as a team player.

4 Agreements

4.1 Agreement with employer

The group has agreed with NTNU and Optimar that a warning/alert system should be created.

4.2 Workplace and resources

- Access to laboratories for Automation and space for bachelor work
- Access to 3d printers, materials and tools needed
- Access to mentors and supervisors

4.3 Group norms - rules of cooperation - attitudes

It can be difficult for the group to estimate the time spent for each phase of a project this size. This may cause the schedule, submitted with the pre-project, to be used as an estimate of what should be done rather than an exact plan of time spent. Further more, it's important to be aware of that unexpected standstill that can occur, such as delays in delivery of equipment.

4.4 Planed work hours

Core work hour Mon-Fri 9-15
Ideal work hour Mon-Fri 8-16
Winter vacation 22.feb - 1.mars - Easter holiday: 3.Apr - 13.Apr

- All work hours and overtime will be logged in time sheet made in Microsoft Excel
- All group members is obligated to work in the holidays, but doesn't need to be in Aalesund.

4.5 Internal problems

As conflicts may arise within the group, it's suitable that the students signs a co-operation agreement at the start of the project. The students can return to this cooperation agreement if any disagreements arise. The agreement has the task of providing for an even distribution of work within the group, and puts each member responsible for their part. If individual members waive their responsibilities, for example by not meeting at agreed times without prior notice, disciplined measures will be implemented. In the worst case, the supervisor can be contacted for the purpose of setting one individual grade on the problematic member of the group.

5 Research

5.1 Preliminary assignment

About 200,000 car accidents in USA alone annually occur by driver falling asleep, blacking out or fainting. The idea is to use modern technology to be able to prevent this accidents from happening. Make use of current technologies that we already have in the cars like smart tachographs or on-board systems to be able to recognize when the driver has passed out, and be able to stop the vehicle, and warn other drivers about the danger.

Methods that can be used:

- Eye tracking
- Head position tracking
- Car direction tracking
- Steering wheel grip tracking
- Heart rate measurement

This technology can potentially save many lives and prevent many accidents from happening.

Ways of directing it to automation and maritime

- Bridge Navigational Watch Alarm System
- Freezer room Watch Alarm System for people
  - Logging people going in to freezer room
  - Camera, skin temperature and time
- Autonomic ships

5.2 Business contacts

5.2.1 Kongsberg Gruppen

Kongsberg Gruppen ASA is an Norwegian, government owned, company providing high-tech systems and solutions to customers in the offshore, oil and gas industries, merchant fleet, defence, aerospace and renewable industries.
Kongsberg Gruppen consists of three businesses areas

- Kongsberg Maritime
- Kongsberg Defence Aerospace
- Kongsberg Digital

Contactperson

Roy-Jostein Fiskerstrand
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Mail: roy-jostein.fiskerstrand@km.kongsberg.com
Acting Head of Project Engineering – Subsea
Kongsberg Maritime CM AS

KONGSBERG

5.2.2 Furuno

Furunos is headquartered in Japan and is the world leader in ship electronics. Furuno Norway was established in 1974 and is a sales and service organization that provides navigational communication and fish breeding equipment to Norwegian, Russian and Brazilian shipyards and shipowners. (https://www.furuno.no/nb-NO/Om-Furuno.aspx 10.01.20)

Thesis from Furuno:

Bridge Navigational Watch Alarm System:

Developing a concept of a bridge Navigational Watch Alarm System by our own view. Furuno will assist with knowledge and test facilities.

Blue Bridge Compact:

Further develop to get Blue Bridge Compact IMO approved for smaller vessels.

Streamlining GUI Research how the nautical personnel uses different aspects of data from there vessel. Nautical personnel needs efficient and streamlined user interfaces giving them the maximal data from a minimal time. How can we as programmers make the best GUI that gives the best overview for the nautical personnel.

Contactperson

Bjørn Juliebø
Tlf: +47 920 83 010
E-post: bjorn.juliebo@furuno.no
Salesleader
(Offshore/kystfartøy)

6 Project description

Optimar is delivering a lot of equipment for freezer rooms on fishing vessels. These freezer rooms is normally operated by one person. Optimar has then heard about accidents where people have been injured due to the cold or other incidents in the freezes. Optimar desires a warning/alert system to solve this problem.

6.1 Project specification

The group's job is to develop a system for freezing rooms in fishing vessels. The ideal solution is a warning system where workers is obligated to use a handheld device that is brought into the freezer when entering. This is to increase the safety of personnel working in the freezer. The handheld device is used by the worker to call for help if needed. The worker also has to press a button on the device every given amount of time, if the button is not pressed, an alarm will go off. To control the system, two HMI screens shall be used, one at the entrance to the freezer room and one at the bridge. Outside the freezer entrance it shall be two charging stations for the two handheld devices.

Finally, a user-friendly interface should be designed where history can be viewed. This user interface should give an overview of who works in the freezer at any given time. If the worker inside the freezer calls for help with the handheld device, an alarm will go off on the user interface. This alarm will also go off if the worker inside the freezer fails to press the button within the given time frame.

Must have	Should have	Could have
Two HMI screens, that communicates with the PLC	Working and user friendly GUI	Timer on how long worker has been in freezer
Portable and rechargeable wireless units for workers	Wireless unit that vibrates after a certain amount of time	Message alarm on phone
Separated system	Wireless unit that blinks to acknowledge time	Wireless units with screen
24 volt powered system	Emergency button to bridge	Units that communicates with freezer room light
UPS/battery if power disappears		
Alarm sound and light if worker fails to report		
Alarm sound if worker is reporting a injury		

6.2 Product Specifications

6.2.1 Required components

There is a lot of equipment that is necessary to carry out in this kind of project. The group have decided to only refer, to the most essential equipment. For a more detailed version, see attachment G.1 sent to Optimar. The equipment that the group will spend most time on is:

Component	Usage	Amount
PLC	Used for the logistics of the system	1
HMI screen	To display events and to check in to the freezer	2
Ethernet switch	For communication between PLC and HMI screens	1
Power supply	Used to power the system	2
Wireless handheld device	Used inside freezer by worker to reset the alarm timer	2
Wireless receiver	To communicate with the handheld device and the PLC	1

6.2.2 PLC - NX1P2-9024DT1

To control the logistics of the system a PLC is required. The NX1P2-9024DT1 was recommended to the group by Optimar, so this is the PLC that was chosen. It is a fairly simple PLC, but has all the required specifications. The PLC is a NX model which means it can be programmed by the Sysmac Studio IDE.

Figure 2: NX1P2-9024DT1

6.2.3 HMI screen - NA5-7W001B

In the bachelor thesis description, it states that two HMI screens is needed. The HMI screens recommended to the group by Optimar was the NA5-7W001B. This is a 7 inch display and is a NA model, which means it also can be programmed by the Sysmac Studio IDE.

Figure 3: NA5-7W001B

6.2.4 Ethernet switch - W4S1-05B

Ethernet is used for communication between the HMI screens and the PLC. Two HMI screens is communicating with the PLC, so a Ethernet switch is required. A switch with 5 ports is used for scalability in the future.

Figure 4: W4S1-05B

6.2.5 Power supply - S8VK-S12024

To power the system, two power supplies is required. One to power the HMI screen at the bridge, and one outside the freezer to power the HMI screen, PLC and the wireless receiver.

Figure 5: S8VK-S12024

6.2.6 Control cabinet

The most important specification when choosing the control cabinet is the size and that the cabinet is made out of a stainless material. To ensure that the cabinet is big enough we chose a cabinet with a height of 500mm, a width of 400mm and a depth of 300mm. If the group struggles to find a control cabinet at an affordable price, Optimar offered to give away one of their cabinets to us.

6.3 Possible wireless handheld device and wireless receiver

6.3.1 Tele-radio

(a) Tiger G2

(b) Puma receiver

TECHNICAL SPECIFICATIONS

- Long range
- Ip rating up to IP66
- Battery rechargeable
- Temperature -20 til +55 °C
- Possible remote antenna withstands -30° degrees

6.3.2 Rfsolutions

Figure 7: Rf-solution unit

TECHNICAL SPECIFICATIONS

- RANGE 2000m
- IP RATING UP TO IP68
- Powered from 3 x AAA Batteries
- Receiver Decoder Operation temperature -10 to +50° Celsius
- Possible remote antenna withstands -30° degrees

6.3.3 FSL Electronics

(a) Wristband Controller

(b) Radio Receiver-DC4

Technical Specifications

- Equipped with a LED indicator
- Protection rating: IP55
- Watch strap, Lanyard or Belt clip
- 2 way link option
- Operational range 150m, optional up to 300m, High power option
- Operating Storage temperature:- 10 C to + 50 C
- Battery: 3V Lithium battery - rechargeable as standard

Technical Specifications

- Outputs:4 individual relay outputs(10A)
- Inputs: 3 (No operation in default firmware)
- Protection rating: IP65
- Power supply:12V-28V DC supply
- Customisation options: Programmable outputs
- Operating Storage temperature:- 10 C to + 50 C
- Accessories: External antenna

6.4 Economical Requirements

Optimar has chosen to give us a budget of approximately 50,000 NOK, but this was a budget that could be exceeded if needed. A list of units with price estimates is attached, see appendix G.1. The final sum will then be adjusted according to whether we encounter problems or if other equipment is needed.

6.5 Methods for developement

As mentioned in chapter 2 (Project organization) the group will use Instagantt to keep track of all assignments.

Everyone in the group has become familiar with lean and knows that this can be important to implement. How we have chosen to implement lean will be attached in the final project report.

6.6 Requirements specification

The main purpose of a project is to achieve an effect of the result. At the second meeting with the client(Optimar), the group asked a number of questions regarding the implementation of the project. It was several points that the group agreed on that were desired to be carried out during the project. For description of what is demanded see section 6.1 Project specification.

6.7 Performance targets

For the group, the performance goals will involve staying within the time frame that is set, as well as keeping control of the time spent during planning phase and the project itself. In addition the group are to build up a knowledge of the different various parts that is used in the project and to gain a good understanding of the system.

6.8 Information gathering

Every member in the group must familiarize themselves with different types of alert systems to gain some insight into how such systems are operated and works.

Gathered:

- How similar systems works today
- Information given by advisors Åge Molnes,Robert Johnsen and Kjell Inge Tomren

To be Gathered:

- Find units that works in freezer room
- Equipment and components that are compatible with each-other

6.9 Analysis of risk

Assessing risk in business or projects that are similar to this, is a continuous process where regular assessments of the danger and problems of the project must be made. This should keep the risk level as low as possible

A mapping and risk assessment of problems doesn't need to be complicated. The scope varies with the size of the workplace and the type of work that the group are working on. The mapping of risk assessment in our project is shown below.

Risk table

Risk level	Low 0 - Acceptable Ok to proceed	Medium 1 - Alarm Take mitigation	High 2 - Unacceptable Seek support	Extreme 3 - Intolerable Project on hold

Frequency of incident	Severity of consequences			
	Very Low Severity	Low Severity	High Severity	Very High Severity
Very often				
Often		- Crush hazard - Workload / stress		- communication problem
Rarely		- Incorrect wiring - Going outside plan - Doesn't work as planed	- Damaged or delayed transport - Unsuspected issues	- Power tool injury - Electrical failure
Very rare		- Incorrect wiring - Short circuit	- Exposure to chemicals - Crush injury - Redesign of idea - Lack of resources	- 230V Electrical shock - Sickness

Risk of project and workers

Problem	Description / Risk mitigation
Communication	Can occur between members of the group or collaborators. Disagreement can occur around hardware, software, project solutions, budget and report. Earlier in this document an agreement regarding disagreements is cleared see section 4.5.
Power tool injure	Every member has experience from using power tools
Damage or delayed transport	The group has worked with several project earlier and is known to work together. The new challenge will be the size and complexity of this project. Because of this, its important to keep a open and direct dialog in the group, plan ahead and plan work hours to reduce stress.
Chrush hazard	When working with fragile components it's important to handle it with care.
230V Electrical shock	Electricity is dangerous to work with, because of this the group needs to follow the ground rules of working with electricity , FSE (Regulations on safety when working in and operating electrical installations).
Incorrect wiring	The group will firs design and control the electrical design in AutoCad before wiring. After one of the members are done wiring there will be a partner check.
Short circuit	Short circuit can damage components. The group will design all electrical circuits with fuses so the damage will be minimal to none.
Exposure to chemicals	The group will not be using any heavy chemicals so exposure should not have any health impact. Protective clothing will be used when needed.
Crush injury	When working with power tools and other equipment's there is a risk of getting fingers crushed. Because of this it's important to handle it with care.

Risk of not finishing in time

Problem	Description / Risk mitigation
Communication	Can occur between members of the group or collaborators. Disagreement can occur around hardware, software, project solutions, budget and report. Earlier in this document an agreement regarding disagreements is cleared see section 4.5.
Workload/stress	The group has worked with several project earlier and is known to work together. The new challenge will be the size and complexity of this project. Because of this, its important to keep a open and direct dialog in the group, plan ahead and plan work hours to reduce stress.
Damage or delayed transport	The group has worked with several project earlier and is known to work together. The new challenge will be the size and complexity of this project. Because of this, its important to keep a open and direct dialog in the group, plan ahead and plan work hours to reduce stress.
Unsuspected issues	In big complex project unsuspected issues can and often will accrue. Because of this it's important to stay one step ahead so this issues will stay minor. We can counter this by doing extensive research and also factor this in to the plan.
Sickness	Sickness is hard to avoids, therefor the importance of personal hygiene is key to for all members to stay healthy.
Going outside of plan	In a big project it's hard to follow a plan point to point. There will be some detours, but her the project manager and weekly plans will be the red guideline through the plan.
Redesign of idea	It's not often the first sketch is the best. Therefore we need to see several solution and do extensive research in the pre-project.
Lack of resource	To move forward it's important that the steps before is taken. We need to plan ahead so that everyone is working and doing productive fork while other aspects is on hold.

6.10 Main work activites

EB - Eilev Brustugun, DE - Daniel Erichsen,

SP - Shajeevan Panchardcharam,

OPT - Optimar

Nr	Acitivity	Responsibility	Time
A1	**Research**	**EB, DE, SP**	**4 Months**
A1.1	Contact companies	DE,SP	1 Week
A1.2	Meetings with companies	EB,DE,SP	2 Weeks
A1.3	Preliminary Report	EB,DE,SP	4 Weeks
A1.4	Meetings with supervisor	EB,DE,SP	4 Months
B1	**Materials**	**EB,DE,SP**	**2 Weeks**
B1.1	Find suppliers	EB,DE,SP	2 Weeks
B1.2	List of parts to order	EB	2 Weeks
B1.3	Order parts	OPT	2 Weeks
C1	**Software**	**EB,DE,SP**	**3 Months**
C1.1	Main program	EB,DE	3 Months
C1.2	Communication PLS	DE,SP	1 Week
C1.3	Communication HMI	SP,EB	1 Week
C1.4	Communication Unites	EB,SP,DE	1 Week
C1.5	GUI	EB,DE,SP	3 Weeks
D1	**Hardware**	**EB,DE,SP**	**1 Months**
D1.1	Cabling	EB,DE,SP	1 Weeks
D1.2	Control Cabinet	EB,DE,SP	3 Weeks
D1.3	Rig	EB,DE,SP	2 Weeks
D1.4	Installation	OPT	2 Days
E1	**Project Management**	**DE,SP**	3 Months
E1.1	Planning	SP,DE	2 Weeks
E1.2	Documentation	EB,DE,SP	3 months
F1	**Testing**	**EB,DE,SP**	**2 Weeks**
F1.1	Software	EB,DE	2 days
F1.2	Hardware	DE,SP	2 days
F1.2	Rig Test	EB,DE,SP	4 days
A,B,C,D,E,F	**All activites**	**EB,DE,SP**	**4 months and 2 weeks**

6.11 Schedule

6.11.1 Time and cost plan

Monday 10.02	Submission of preliminary-project.
Every Tuesday	Weekly Progress meeting
Wednesday 20.05	Submission of the project report (electronic and paper version).
Date undefined–	Oral Presentation

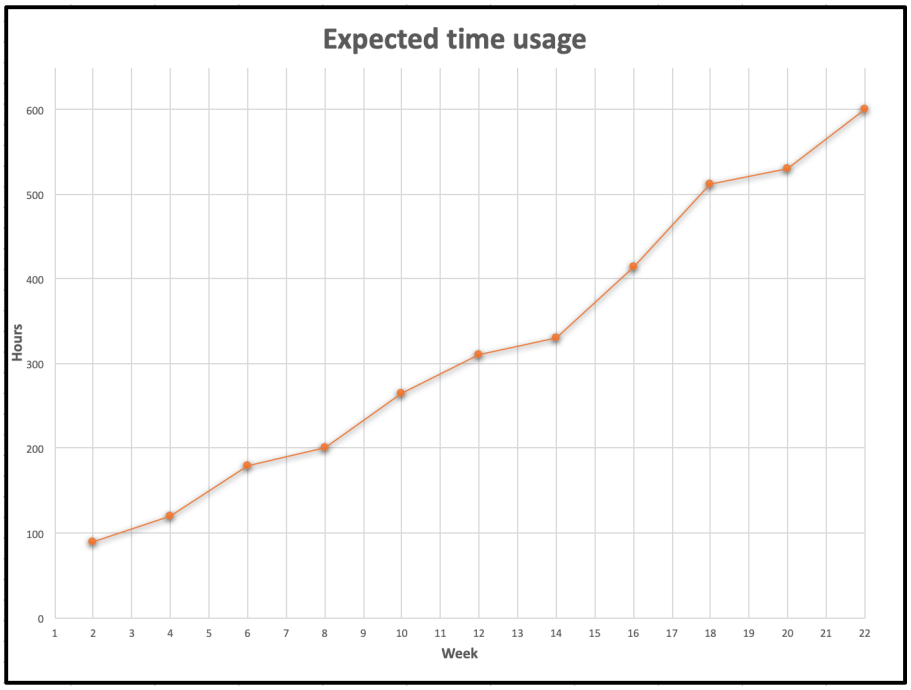


Figure 9: Timeusage

6.11.2 Main Plan

It's very important that we follow the structured overview and the plan we have set up. So that we have a clue to what has been done and what needs to be worked on. If we follow the plan and everyone is working according to the plan at all times, we will always have some form of progress.

In this plan there will always be a person responsible for the task. This does not necessarily mean that the task is carried out by this person, but that he is responsible for the task being carried out.

The plan shown in the picture below is made in Instagantt and Asana, which have been linked together. For a total PDF view see appendix B.1

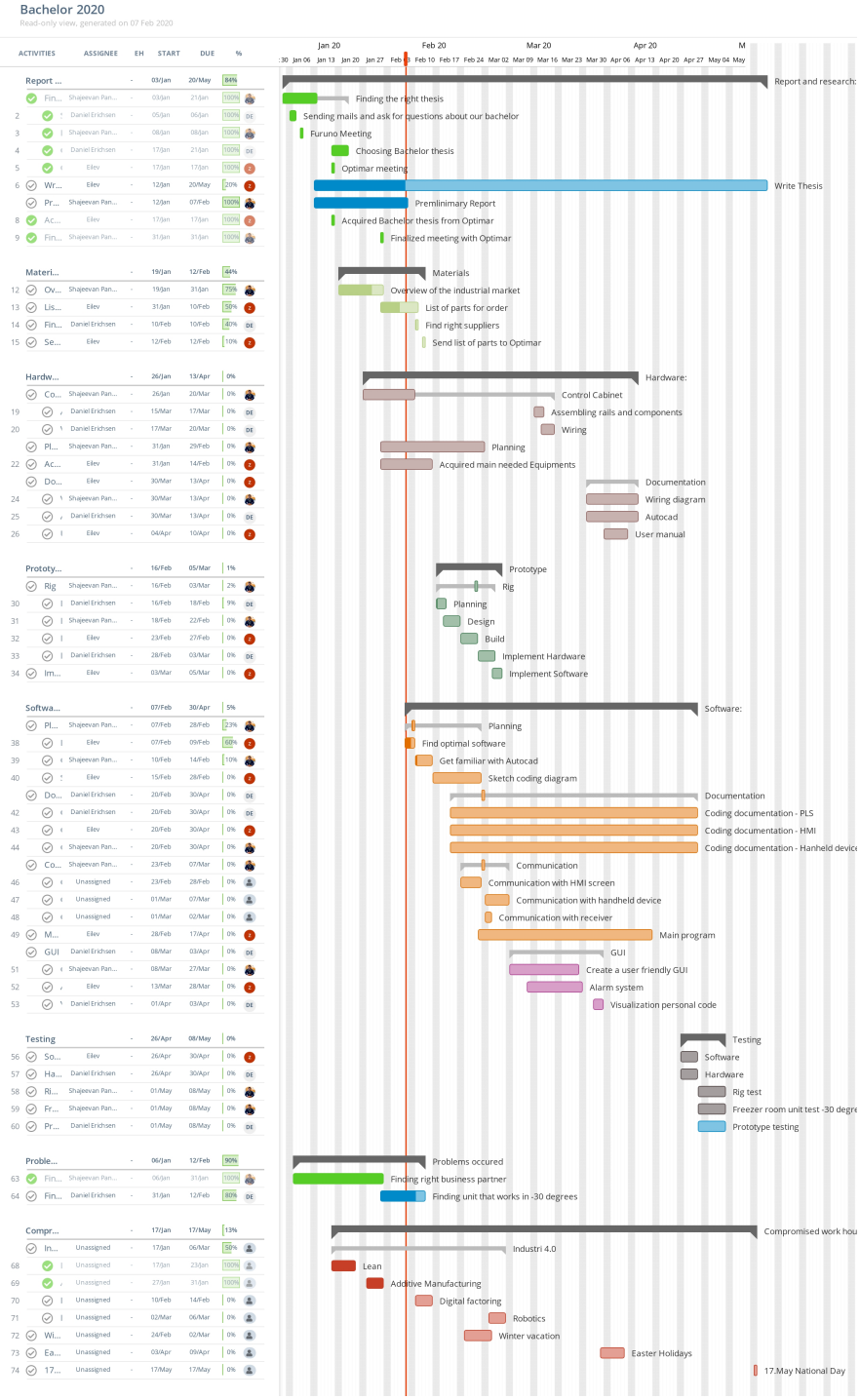


Figure 10: Gant Diagram

7 Documentation

7.1 Reports and technical documents

In documentation every tool and material that is used will be noted, and also why these tools and materials were used. The data sheet of every component will be noted to make it easy to access documentation of the components. Every source that is used will also be noted in the documentation.

When testing the solution, a small report will be written. This report will describe the details of the test and the outcome. Both the tests that succeeds and the tests that fails will be documented. The report will also document what caused the failure and what improvements can be made to prevent the failure.

The group will work on the project at the university workshop where the group has access to tools and equipment, like 3d printers and laser cutters. Materials and tools will be stored at the workshop where only authorised personnel can access. All the physical documents, like drawings and such, will be stored in a physical folder.

When the project is finished, the group will construct a user manual for the system. The user manual will describe roughly how the system works and how to use it.

8 Scheduled meetings and reports

8.1 Meetings

8.1.1 Project meetings

Meetings with supervisor will occur every Tuesday 10-11 o clock. During these meetings the supervisor and the group will discuss the status of the project, issues that occurred and possible solutions.

8.1.2 Progress report

Every week the group will write a report that explains the status of the project. The report will include all the tasks that has been completed, the problems that occurred and how the group plan to fix it. The report will also include a rough plan describing the tasks occurring the next week.

9 Scheduled deviation treatment

As mentioned earlier, everyone in the group will work closely according to the plan that has been made. If there are delays in work, we will be able to adjust so that all work tasks are done according to plan. Throughout the project, adjustments will be made to plan, in proportion to time. When there are adjustments to the plan, the group will have a weekly meeting and discuss this.

The project accommodates areas that the group doesn't have previous experience of. The group have therefor envisage that different challenges may arise during the project. Because of this there has been meetings were all members have thought and reflected on various problems that may encounter.

If one member of the group struggles to complete a task, the rest of the group will assist in doing the specific task that the team member is struggling with. There will always be someone who has been given a task and someone who is responsible for the task being done.

10 Equipment requirements

Components and equipment's for project execution:

List of components

Components	Description
PLC - NX1P2-9024DT1	Omron
HMI screen - NA5-7W001B	Omron
Ethernet switch - W4S1-05	Omron
Power supply - S8VK-S12024	Omron
UPS S8BA-24D24D480SBF UPS battery S8BA-S480L Control cabinet	In case of power loss, Omron In case of power loss, Omron
Chosen handheld device	See section 6.3 Possible wireless handheld device and wireless receiver
Antenna	Antenna going to freezer room
Cabling	24V cabling, not more than 0.75 mm^2*needed*
Rails	Mounting Terminal blocks, PLC and other equipment to cabinet
Terminal blocks	To route and connect cables
connection nipple	To bring cables through walls or control cabinet

10.1 Software

In order to carry out the project several programs have to be used. Programs as AUTOCAD, is a type of software that optimar expect the group to be familiar with. Main softwares that will be used during the project assignment :

- Autocad
- Office 365
- PCSCHEMATIC
- LaTeX
- Sysmac studio

A Attachment - Cooperation Agreement

A.1

NTNU

Cooperation Agreement

This agreement applies to the following students at the Norwegian University of Science and Technology at Aalesund.

Eilev Brustugun, Daniel Erichsen, Shajeevan Panchardcharam

Commitments

The agreement concerns the groups collaboration on planning, and reporting of the the bachelor project. The bachelor project is held during the last year of the student course of study.

With regard to work and problems within the group, the group have come to the conclusion that the majority decides. If everyone in the group disagrees, the group leader will be the member who makes the final decision. In addition, the whole group has a collective performance responsibility, so the project can be completed as planned.

Eilev Brustugun

Shajeevan Panchardcharam

Daniel Erichsen

Sted: Ålesund

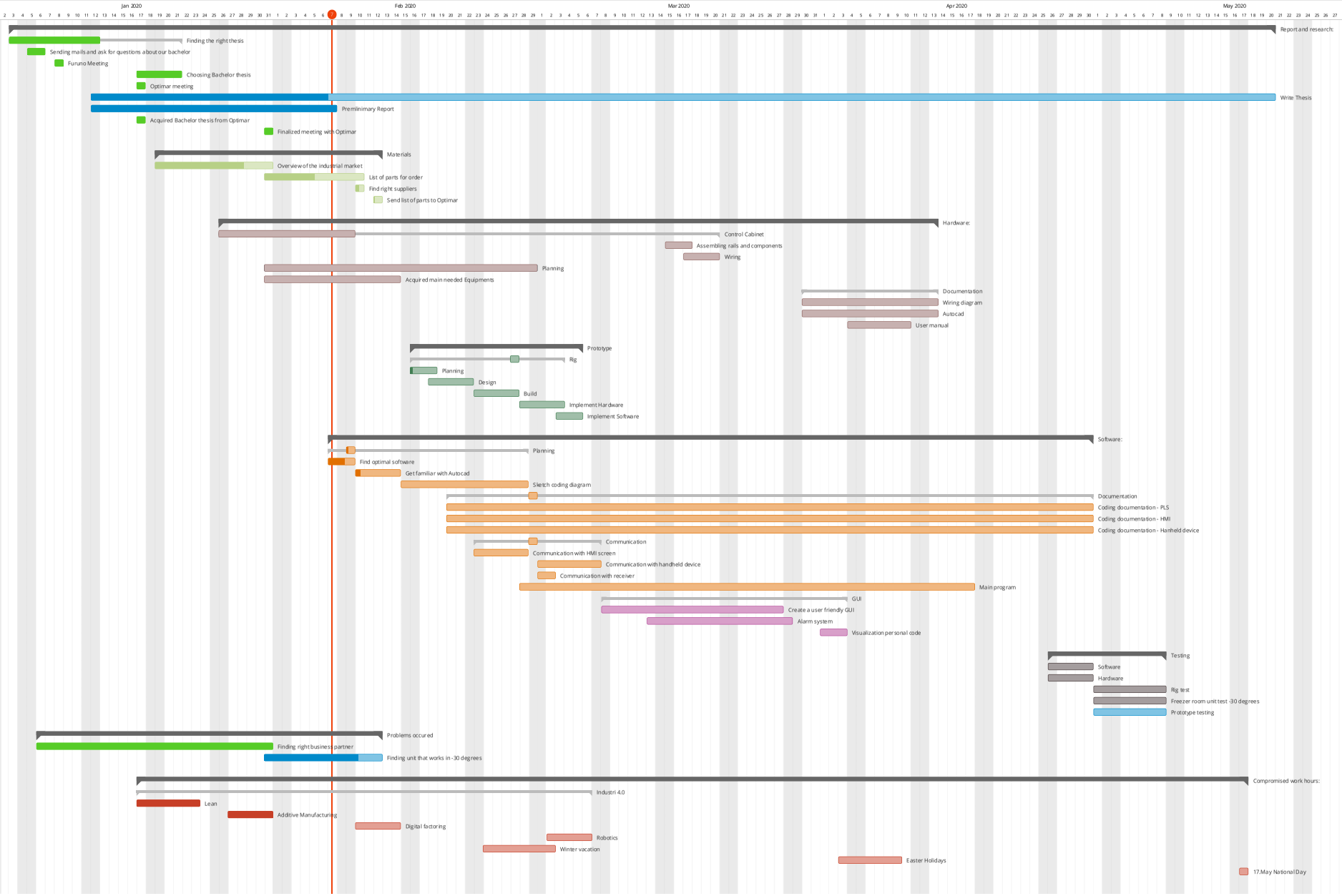
Dato: 29.01.20

NTNU

Bachelor 2020

Read-only view, generated on 07 Feb 2020

	ACTIVITIES	ASSIGNEE	EH	START	DUE	%
	Report and research:		-	03/Jan	20/May	8.4%
	Finding the right thesis	Shajeevan Pan...	-	03/Jan	21/Jan	100%
2	Sending mails and ask for ques...	Daniel Eriksen	-	05/Jan	06/Jan	100%
3	Furuno Meeting	Shajeevan Pan...	-	08/Jan	08/Jan	100%
4	Choosing Bachelor thesis	Daniel Eriksen	-	17/Jan	21/Jan	100%
5	Optimar meeting	Elev	-	17/Jan	17/Jan	100%
6	Write Thesis	Elev	-	12/Jan	20/May	20%
	Premilinimary Report	Shajeevan Pan...	-	12/Jan	07/Feb	100%
8	Acquired Bachelor thesis from Opti...	Elev	-	17/Jan	17/Jan	100%
9	Finalized meeting with Optimar	Shajeevan Pan...	-	31/Jan	31/Jan	100%
	Materials		-	19/Jan	12/Feb	69%
12	Overview of the industrial market	Shajeevan Pan...	-	19/Jan	31/Jan	75%
13	List of parts for order	Elev	-	31/Jan	10/Feb	50%
14	Find right suppliers	Daniel Eriksen	-	10/Feb	10/Feb	87%
15	Send list of parts to Optimar	Elev	-	12/Feb	12/Feb	10%
	Hardware:		-	26/Jan	13/Apr	0%
	Control Cabinet	Shajeevan Pan...	-	26/Jan	20/Mar	0%
19	Assembling rails and compone...	Daniel Eriksen	-	15/Mar	17/Mar	0%
20	Wiring	Daniel Eriksen	-	17/Mar	20/Mar	0%
	Planning	Shajeevan Pan...	-	31/Jan	29/Feb	0%
22	Acquired main needed Equipments	Elev	-	31/Jan	14/Feb	0%
	Documentation	Elev	-	30/Mar	13/Apr	0%
24	Wiring diagram	Shajeevan Pan...	-	30/Mar	13/Apr	0%
25	Autocad	Daniel Eriksen	-	30/Mar	13/Apr	0%
26	User manual	Elev	-	04/Apr	10/Apr	0%
	Prototype		-	16/Feb	05/Mar	1%
	Rig	Shajeevan Pan...	-	16/Feb	03/Mar	2%
30	Planning	Daniel Eriksen	-	16/Feb	18/Feb	9%
31	Design	Shajeevan Pan...	-	18/Feb	22/Feb	0%
32	Build	Elev	-	23/Feb	27/Feb	0%
33	Implement Hardware	Daniel Eriksen	-	28/Feb	03/Mar	0%
34	Implement Software	Elev	-	03/Mar	05/Mar	0%
	Software:		-	07/Feb	30/Apr	5%
	Planning	Shajeevan Pan...	-	07/Feb	28/Feb	23%
38	Find optimal software	Elev	-	07/Feb	09/Feb	99%
39	Get familiar with Autocad	Shajeevan Pan...	-	10/Feb	14/Feb	10%
40	Sketch coding diagram	Elev	-	15/Feb	28/Feb	0%
	Documentation	Daniel Eriksen	-	20/Feb	30/Apr	0%
42	Coding documentation - PLS	Daniel Eriksen	-	20/Feb	30/Apr	0%
43	Coding documentation - HMI	Elev	-	20/Feb	30/Apr	0%
44	Coding documentation - Hanhe...	Shajeevan Pan...	-	20/Feb	30/Apr	0%
	Communication	Shajeevan Pan...	-	23/Feb	07/Mar	0%
46	Communication with HMI screen	Unassigned	-	23/Feb	28/Feb	0%
47	Communication with handheld ...	Unassigned	-	01/Mar	07/Mar	0%
48	Communication with receiver	Unassigned	-	01/Mar	02/Mar	0%
49	Main program	Elev	-	28/Feb	17/Apr	0%
	GUI	Daniel Eriksen	-	08/Mar	03/Apr	0%
51	Create a user friendly GUI	Shajeevan Pan...	-	08/Mar	27/Mar	0%
52	Alarm system	Elev	-	13/Mar	28/Mar	0%
53	Visualization personal code	Daniel Eriksen	-	01/Apr	03/Apr	0%
	Testing		-	26/Apr	08/May	0%
56	Software	Elev	-	26/Apr	30/Apr	0%
57	Hardware	Daniel Eriksen	-	26/Apr	30/Apr	0%
58	Rig test	Shajeevan Pan...	-	01/May	08/May	0%
59	Freezer room unit test -30 degrees	Shajeevan Pan...	-	01/May	08/May	0%
60	Prototype testing	Daniel Eriksen	-	01/May	08/May	0%
	Problems occured		-	06/Jan	12/Feb	93%
63	Finding right business partner	Shajeevan Pan...	-	06/Jan	31/Jan	100%
64	Finding unit that works in -30 degre...	Daniel Eriksen	-	31/Jan	12/Feb	80%
	Compromised work hours:		-	17/Jan	17/May	13%
	Industri 4.0	Unassigned	-	17/Jan	06/Mar	50%
68	Lean	Unassigned	-	17/Jan	23/Jan	100%
69	Additive Manufacturing	Unassigned	-	27/Jan	31/Jan	100%
70	Digital factoring	Unassigned	-	10/Feb	14/Feb	0%
71	Robotics	Unassigned	-	02/Mar	06/Mar	0%
72	Winter vacation	Unassigned	-	24/Feb	02/Mar	0%
73	Easter Holidays	Unassigned	-	03/Apr	09/Apr	0%
74	17.May National Day	Unassigned	-	17/May	17/May	0%



B B.1

C Attachment - Meeting Report

C.1

NTNU

Optimar AS

Minutes for January 17, 2020

Present: Åge Martin Molnes, Robert Johnsen, Daniel Erichsen, Shajeevan Panchardcharam, Eilev Brustugun

Agenda

This meeting covered a possible bachelor thesis that Optimar AS presented for the group.

Introduction

Optimar AS is a company that delivers tools and equipment to the boat industry, including freezers. These freezers keeps a temperature of around -30 degrees and the workers stays in this freezer alone for around 20-30 min at a time. Accidents has occurred in these freezer previously, where the workers has not been able to alert the crew members. Because of these accidents occurring, Optimar wants the group to construct an alert system that monitors the personnel entering these freezers.

Plan

Optimar showed the group a drawing of the ship, and presented a rough plan of how the system should work.

- Freezer door has to be monitored
- Worker has to log every time he enters the freezer
- A handheld wireless device that the worker has to take with him inside the freezer. This device is used to log every x amount of time.
- HMI screen on bridge of the boat
- Separate 0V and ground connection
- 24V system
- Charging of the handheld device
- Can be adapted to different boats
- The system needs to be isolated from the other systems on the boat.
- UPS in case of power outage

D Attachment - Meeting Report

D.1

NTNU

Furuno AS

Minutes for January 08, 2020

Present: Bjørn Juliebø, Daniel Erichsen, Shajeevan Panchardcharam, Eilev Brustugun

Agenda

This meeting covered a possible bachelor thesis that Furuno AS presented for the group.

Introduction

Furuno AS delivers bridge systems that are already IMO approved, which are designed for big ships. Since the system is already IMO approved, there is no point to develop on it further. Furuno also has some systems that are designed for smaller boats, these systems are not IMO approved. So a possible bachelor thesis could be to create a system for these boats that are IMO approved.

Plan

Furuno is prepared to let the group borrow their bridge system, designed for small boats. The thesis could consist of the group improving this system.

E Attachment - Preparation and meeting Optimar

E.1

NTNU

Preparation for meeting Optimar

Minutes for preparation Optimar 31.01.2020

Present: Sent to: Åge Martin Molnes Daniel Erichsen and Eilev Brustugun

Bachelor thesis description

The group's job is to develop a system for freezing rooms in boats. The ideal solution is a warning system where workers are obligated to use a handheld device that is brought into the freezer when entering. This is to increase the safety of personnel working int he freezer. Two HMI screens shall be used, one at the entrance to the freezer room and one at the bridge. Outside the freezer entrance it shall be a charging station with one or number of units. The unit should consist of buttons and or if possible a screen. This unit should communicate with HMI screens mounted at the entrance of the freezing room and Bridge.

Preliminary idea

Handheld wireless unit

- Handheld wireless unit with three buttons, red, green and yellow. Vibrates before worker needs to acknowledge that's all good.
- If worker is stuck,, hurt or worse, 2 buttons will be pressed at the same time to alert bridge personnel.
- Handheld wireless unit withe one button, press to acknowledge and hold to alert.

HMI screens and charging station

- Worker approach freezer door, picks up handheld unit from charging station. Worker presses his name on HMI screen. when all of this is done a timer will start on the HMI outside the freezer and on the bridge. Afther a given time, the handheld unit will vibrate and a massage displaying name on worker and a warning light on the bridge and outside the freezer. The warning will develop to an alarm in form of light and sound if worker does not press and by this acknowledge all ok.
- For this to work over a long period of time, when worker is drilled in other routines its important for a solution that can't be tricked.
  - Freezer light turns on when worker is logged in
  - Personal password to "log into freezer

Summary of approach

- 2x HMI screens
  - Display bridge
  - Display outside freezer door
- PLC for control
- Wireless handheld unit with 230V charging
- Receive for wireless unit
- 24V control system
- Alarm with light and sound

clearance of issues

Components

- PLC, controller? What type of manufacturer
- Handheld wireless unit - Suppliers Optimar is working with
- Suppliers Optimar is working with
- Who orders components?
- Construct or order control capinet?

Workplace

- Where are we going to work and test?
- Does optimar have any test facilities

Budget

A budget we may need to follow according to components ordering and so on.

Prototyping

- What does Optimar want from the project
- Building a rig for test and prototype
- what if the project runs out of time?

F Attachment - Meeting Optimar

F.1

NTNU

Optimar AS

Minutes for January 31, 2020

Present: Robert Johnsen Daniel Erichsen and Eilev Brustugun

Agenda

This meeting is planed as an conclusive and affirmative meeting around given aspects of the bachelor thesis. Students from NTNU Aalesund and Optimar have arrived an agreement for the bachelor thesis, and this meeting is to clear up given aspects regarding the pilot project of the thesis. Before the meeting a plan was arranged and sent to optimar.(attachment x)

Introduction

Optimar AS is a company that delivers tools and equipment to the boat industry, including freezers. These freezers keeps a temperature of around -30 degrees and the workers stays in this freezer alone for around 20-30 min at a time. Accidents has occurred in these freezer previously, where the workers has not been able to alert the crew members. Because of these accidents occurring, Optimar wants the group to construct an alert system that monitors the personnel entering these freezers.

Plan

The group initiates the meeting by explaining there plan for solving the thesis given by Optimar. The group explains the solution for Optimar, what type of units that are needed and system to use. Optimar approves the solution with minor adjustments. For total solution see plan for meeting. (attachment x)

Adjustments

- Wireless handheld unit should be constructed so a worker can handle alarm signals withe one hand.
- Two relays for acknowledging communication with wireless unit. This in terms of redundancy
- Wireless receiver inside freezer. This is because the freezer is too insulated for communication through the walls.
- Not possible to manage freezer lighting
- Charger for wireless unit mounted on the side of control cabinets
- User friendly GUI
  - Personal code to check in to freezer
  - Worker 2 checks of as worker 2.
  - Worker 1 on charge at panel

- Workers are inside freezer approximately 20 min, 4 times a day, but max 1 hour.
- Worker reports every 5 min, but possible to change variable. (Password protected)

Budget

The budget is flexible, but Optimar is approximating 50 000,- for all units and work needed to get the project finished. The final budget will be set when the group has handed in a full component list needed with all parts, pricing and providers.

Components

Components Optimar wants or recommends us to use:

- PLS – Omrom
- HMI – Omrom
- Wireless unit - Teleradio recommended from Optimar
- Receiver - Free choice
- control cabinets - Optimar makes there own or deliverd from Rital (Requirements for AE stainless cabinet)
- HMI at bridge - Cut out of HMI

Plan ahead

The plan ahead for the bachelor will be to gather information on products and solutions that was discussed earlier in the meeting. When the pre-project is done, Optimar wants a component list of all the units needed to finish the project. The component list will be sent to Optimar, where they will be responsible for ordering. Further agreement is also that the group is going to build a test rig to test, control and show our solution. This compact test setup and all engineering behind will be the final solution given to Optimar.

G Attachment - Component list

G.1 Medlemmer

Shajeevan Panchardcharam
Eilev Brustugun
Daniel Erichsen

07.02.20

Komponentliste

NTNU

NTNU

OMRON

OPTIMAR

Desired units and components

The components listed below are the ones we want to order. The group has gained knowledge up on each component and agreed that these will fit perfectly. Page 2,3 and 4 show some different handheld devices that we think may be ideal, here we are happy to receive tips if you have any experience from any of these.

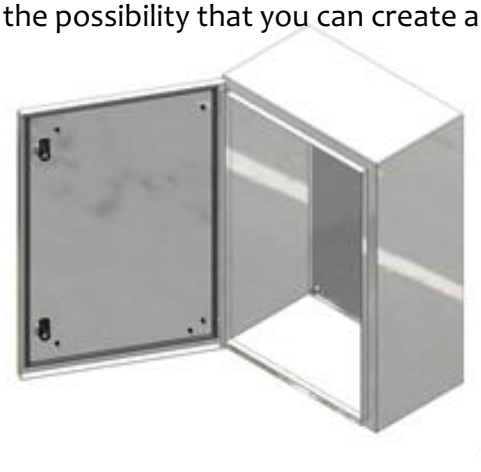
Here are the products from Omron we want to order

Komponent	Produkt nummer	Type betegnelse	Pris per stk	Antall
PLS	672498	NX1P2-9024DT1	7695	1
HMI	392725	NA5-7W001B	14520	2
Ethernet switch	274905	W4S1-05B	3467	1
Strømforsyning	669511	S8VK-S12024	1079	2
UPS	683502	S8BA-24D24D480SBF	2503	1
Batteri til UPS	683501	S8BA-S480L	4985	1
Håndholdt enhet	-	-	-	-

Final sum without cabinet and handheld device: **48 769kr**

Potensiell SKAP :

The link below shows the control cabinet we have looked at: https://www.efa.no/produkt/34680288/veggskap-rustfritt-600x400x300. But we have also thought about the possibility that you can create a cabinet for us.



Medlemmer
Shajeevan Panchardcharam
Eilev Brustugun
Daniel Erichsen

Komponentliste

07.02.20

NTNU

Handheld devices that may be potential:

- Tiger G2 med skjerm
- Tiger G2 uten skjerm
- Wearable industrial remote control
- RFsolutions

Tiger G2

(a) Tiger G2

(b) Puma receiver

TECHNICAL SPECIFICATIONS

- Long range
- Ip rating up to IP66
- Battery rechargeable
- Temperature -20 til +55 °C
- Possible remote antenna withstands -30° degrees

Medlemmer
Shajeevan Panchardcharam
Eilev Brustugun
Daniel Erichsen

Komponentliste

07.02.20

NTNU

Wearable industrial remote control

(a) Wristband Controller

(b) Radio Receiver-DC4

Technical Specifications

- Equipped with a LED indicator
- Protection rating: IP55
- Watch strap, Lanyard or Belt clip
- 2 way link option
- Operational range 150m, optional up to 300m, High power option
- Operating Storage temperature:- 10 C to + 50 C
- Battery: 3V Lithium battery - rechargeable as standard

Technical Specifications

- Outputs:4 individual relay outputs(10A)
- Inputs: 3 (No operation in default firmware)
- Protection rating: IP65
- Power supply:12V-28V DC supply
- Customisation options: Programmable outputs
- Operating Storage temperature:- 10 C to + 50 C
- Accessories: External antenna

Medlemmer
Shajeevan Panchardcharam
Eilev Brustugun
Daniel Erichsen

07.02.20

NTNU

Komponentliste

RFsolutions

Figure 7: Rf-solution unit

TECHNICAL SPECIFICATIONS

- RANGE 2000m
- IP RATING UP TO IP68
- Powered from 3 x AAA Batteries
- Receiver Decoder Operation temperature -10 to +50° Celsius
- Possible remote antenna withstands -30° degrees

H Attachment - Eilev Circulum Vitae

H.1

NTNU

Personopplysninger

Navn: Eilev Brustugun

Født: 31. Juli 1995

Adresse: Dalavegen 78, 2690 Skjåk

Telefon: 95875903

Skolegang

2011/2012 – Nord Gudbrandsdal VGS avd. Otta - idrettsfag VG1

2012/2013 – Vinstra videregående skole - elektrofag VG1

2013/2014 – Vinstra videregående skole - 2DEL VG2

2014/2015 – Vinstra videregående skole - 3DAT VG3

2017-2020 – NTNU Ålesund - Automatiseringsteknikk

Erfaring

Utplassering og sommerjobber:

Har hatt sommerjobb hos Brustugun Brønnboring AS i sommeren 2014. Her fikk jeg lært: boring og styring av borerigg, sveise, montering av pumpe.

Jeg har vert utplassert på Ottadalen installasjon og Interfil AS.

Har vert lærling og ansatt som dataelektroniker og IT-medarbeider i Interfil AS fra sommer 2015 til og med 2020.

Kurs

Varme arbeider sertifikat

Opplæring i FSE

Opplæring i førstehjelp

Erfaring jeg har fått av personlige prosjekter, skole og jobb

Windows server 2008/2012/2019

SQL server

Exchange server

Terminal server

Active Directory

Dynamics AX 2012

Data nettverk

Innbruddsalarm og brannalarm

Programmering av adgangskontroll

Sanntids programmering

Computer Vision

Kunstig intelligens

Programmeringsspråk og teknologier:

- Python
- C#
- Javascript
- C++
- Visual Basic
- Java
- Matlab
- Arduino
- HTML
- Swift
- SQL
- Powershell
- Node JS
- OpenCV

I Attachment - Daniel Circulum Vitae

I.1

NTNU

Daniel Erichsen

H.W RIIS VEG 3, 6007 Ålesund / Haugavegen 14, 5354 Straume
Tlf: 41643395 | E-post: danielerichsen@hotmail.com
Født: 08.mai.1994

U T D A N N I N G

Bachelor Automatiseringsteknikk	**NTNU Ålesund** **Aug 2017 – Jul 2020**
Forkurs til 3-årig ingeniør	**Høgskolen i Bergen** **Aug 2016 – Jun 2017**
Fagbrev Automasjon	**Statoil ASA** **Sep 2013 – Feb 2015**
VG3 Automasjon	**Sotra videregående skole** **Aug 2012 – Jun 2013**
VG2 Automasjon	**Sotra videregående skole** **Aug 2011 – Jun 2012**
VG1 Elektro	**Sotra videregående skole** **Aug 2010 – Jun 2011**

A R B E I D S E R F A R I N G

Odeon Kino *Skiftleder*	**Okt 2018** →
Sommervikar GK Norge *Bygg-automasjon*	**Sommer 2019**
LOS Elektro *Elektriker*	**jun 2018 – Aug 2018**
Dolly Dimples *sjåfør*	**Sep 2017 – Jun 2018**
Clas Ohlson *Butikkmedarbeider*	**Okt 2016 – Aug 2017**
Forsvaret *Bakkeutstyrssoldat*	**Sep 2015 – Aug 2016**
BME Installasjon AS *Hjelpearbeider*	**Mar 2015 – Jun 2015**
Statoil ASA *Lærling Kollsnes*	**Sep 2013 – Feb 2015**

Fortsettes neste side

NTNU

Hjelpearbeider GK Norge Sommer 2013
Bygg-automasjon

ICA Supermarked Aug 2012 – Jun 2013
Deltidsarbeider butikk

Hjelpearbeider GK Norge Sommer 2012
Bygg-automasjon

ANNEN ERFARING

- Arbeidet med måleavdeling Kollsnes
- Eksamen elektro
- Sertifikat klasse B, BE og T
- Truckfører bevis T1 - T4

KURS

- FSE Kurs
- Vekteropplæring trinn 1
- Avinor kurs Ørland hovedflystasjon
- Førstehjelp nivå 2
- Fittings og small bore tubing OLF 120 (Gyldig til 14.01.2018)
- Grunnleggende Ex og Exi (Gyldig til 31.01.2019)
- Control valve + positioner
- Praktisk reguleringsteknikk
- Generell mengdemåling
- Fallsikring med nedfiringsdel

REFERANSER

Bjørn Faleide: Butikksjef | Clas Ohlson Sartor | Mobil: 97542450
Beathe Kvalsvik Breiviken: Senterleder | Odeon Kino | Mobil: 98629707

J Attachment - Shajeevan Circulum Vitae

J.1

Shajeevan Panchardcharam

Kjonebråten 6, Asker

91 74 54 23

vpshajeevan@gmail.com

Født: 19. September 1996

NTNU

UTDANNING

Aug. 2017 – pågående

Bachelorgrad Automasjonsingeniør

Fakultet for informasjonsteknologi og elektroteknikk, NTNU

- Studieretning Automatiseringsteknikk
- Bacheloroppgave: Brovakt deteksjon

Jan. 2016 – Des. 2017

Ingeniørbataljonen

Hærens Båttropp, Norske Forsvaret

Aug. 2011 – Mai.2015

Studiespesialisering VGS

Valler Videregående skole

ARBEIDSERFARING

2018 – pågående

Tech Salgs konsulent

Elkjøp, 6019 Ålesund

- Arbeidsoppgaver: Salg av lyd og bilde, data, tele, gaming og kundebehandling.

2018 – 2018

Salgskonsulent

Sector Alarm, 6018 Ålesund

- Arbeidsoppgaver: Salg av alarm til bolig og kundebehandling.

2017 – 2017

It support

Lovisenberg sykehus, 0456 Oslo

- Arbeidsoppgaver: Hjelpe til med innføring av workplace.

2017 – 2017

Oversetter

Enkeltmannsforetak

- Arbeidsoppgaver: Oversette arbeidsoppgave fra norsk til engelsk for dataingeniører i utlandet.

2017 – 2017

Låseansvarlig - Butikkmedarbeider

Rema 1000 Drengsrud, 1383 Asker

- Arbeidsoppgaver: Ansvar for drift av butikken da kjøpmann var på ferie, håndtere bestillinger og forsendelser, varepåfylling og kundebehandling.

2017 – 2019

Låseansvarlig - Butikkmedarbeider

Rema 1000 Borgen, 1388 Borgen

- Arbeidsoppgaver: Varepåfylling, kundebehandling og skiftleder.

2014 – 2017

Butikkmedarbeider

Rema 1000 Billingstad, 1383 Asker

- Arbeidsoppgaver: Kasserer, kundebehandling og varepåfylling.

2015 – 2016

Trommeinstruktør

Borgen skolekorps, 1388 Borgen

- Arbeidsoppgaver: Instruktør for trommeslagere.

2014 – 2015 **Kjøkken assistent**
Bølgen og Moi, 1337 Sandvika
- Arbeidsoppgaver: Hjelpe til med enkle retter og oppvask.

2013 – 2014 **Svømmeinstruktør**
Asker svømmeklubb, Risenga svømmehall
- Arbeidsoppgaver: Instruktør for barn i alderen 6-12 år og dialog med foresatte.

2011 – 2013 **Svømmeinstruktør**
Asker svømmeklubb, Landøya Svømmehall
- Arbeidsoppgaver: Instruktør for barn i alderen 6-12 år og dialog med foresatte.

SERTIFIKATER

2018 **Båtførerbevis**
Tryggombord, Drammen

2016 **Kranførerbevis**
Det norske forsvaret

2016 **Truckførerbevis**
Det Norske Forsvaret

2014 **Førerkort, klasse B**
Billingstad, Slependen

Kursbevis

2019 **Salgskurs- Telecom and Audio video**
Samsung, Elkjøp AS

2018 **Salgskurs- Telecom**
Telia, Elkjøp AS

2018 **Salgskurs**
Sector Alarm, Oslo

2016 **Vekterkurs**
NOKAS

2016 **Millitærbil**
Det Norske Forsvaret

2016 **Millitær båtførerbevis nivå 1 og 2**
Det Norske Forsvaret

2016 **Millitær elvekurs med båt**
Det Norske Forsvaret

2016 **Sanitetskurs nivå 1 og 2**
Det Norske Forsvaret

2012 **Førstehjelpskurs**
Asker svømmeklubb

PERSONLIGE FERDIGHETER OG KOMPETANSE

Språk	Norsk – Flytende skriftlig og muntlig Engelsk – Flytende skriftlig og muntlig Tamilsk – Flytende skriftlig og muntlig Fransk – Lavt nivå

IT-ferdigheter			
	NX siemens	Matlab	Fusion 360
	Python	Java	C
	Microsoft Office	LaTeX	

ANNET

Meritter	Vinner av ZumoRobot Challenge NTNU 2018
Interesser	Kommunikasjon og salg, fotball, trommer, fotografi, musikk,

REFERANSER

Susann Rudolph	Avdelingsleder, Elkjøp Breivika 45 25 00 44
Tore Lunde	Varehussjef, Elkjøp Breivika 95 14 57 01
Linn Larsen	Kjøpmann, Rema 1000 Borgen 95 17 45 84
Tone Hærem	It ansvarlig, Lovisenberg Sykehus 98 20 75 12 tone.haerem@lds.no

Safety System for workers in freezer room

NTNU
Norwegian University of
Science and Technology