

HNC Project 2111222

by William Utting

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Table of Contents

Introduction	3
Background Research	4
Methods of Protection	4
Conclusion	5
Specification	6
Planning	7
Implementation	13
Testing	28
Conclusions and Recommendations	30
Citations	31

Table of contents needs to be more detailed

List of figures should be included

Introduction

The aim of this project is to research potential solutions to safety measures for industrial machinery and provide a suitable system to protect an individual against a hazardous, industrial environment. This will entail: the setup of the safety device; interfacing the safety device with a programmable logic controller (PLC) and providing the safety device with a method of shutting down the machine and restarting once the protected area is secure.

Intro includes good points

Background Research

As outlined in the Health and safety at Work act, an employer must provide and upkeep a safe working environment for their employees (GOV.UK, 1974). There are many machines in an industrial workplace that can cause serious harm or even death. This can occur when an operator or other person approaches a machine when it is running and becomes entrapped in the mechanism. Therefore it is important to protect individuals in the proximity of the machine (OSHA.gov).

Relevant points made

Methods of Protection

Alongside suitable training and attire, a major aspect of protection is to implement safety guards on machinery. These protect the operator from moving parts of the machine (www.hse.gov.uk). However, there are some cases where guards do not function well. Such as when using a robotic arm to automate a task. In this case, a large area surrounding the machine is unsafe, therefore fences and gates must be employed to restrict the area (education.vex.com, 2024). To protect an entrance or opening to a machine a light curtain can be used. *Correctly cited*

Light Curtains

Light curtains consist of three main components: The emitter, receiver and control unit. The emitter emits beams of light which are detected by the receiver. If the receiver stops detecting a beam, the machine is stopped. Light curtains offer the protection of a physical guard while maintaining the visibility of the operator (Association for Advanced Automation, 2024). *Correct citation*

There are some issues regarding the use of a light curtain. They can be set up too close to the hazard to provide adequate protection. A light curtain also does not protect against the machine if it ejects material towards the operator (Tom Rowse, 2019). Using a light curtain to protect a large area requires them to be used as gates at entrances to the area with fencing protecting the rest (www.oem.co.uk, 2021). Due to the proximity of the device to pedestrian traffic and the positioning required for the receivers to function there could be instances where the curtain is knocked out of position or damaged by a pedestrian. The curtain does not monitor the area but the entrances to the area, a machine could malfunction within the area and cause a hazardous environment for operators even if the machine is shut down upon entry.

Very good points made relevant to the objective of the project. This could be considered as an alternative solution and should include a diagram to support the explanation.

Safety Scanners

Correct citation A safety scanner monitors a two dimensional plane and detects when an object enters a protected zone. They can be used with machinery to monitor and secure the surrounding area (www.automation24.co.uk). The unit is much smaller in size than a light curtain and can actively protect a larger area. A safety scanner is much more flexible and adaptable than a light curtain. They can be used as area protection, access protection and proximity protection onboard autonomous vehicles. Multiple areas of protection can be protected by a single unit and switching between zone configurations or creating new zones can be conducted using software via remote connection or at the scanner (www.keyence.co.uk, 2024).

Good point here

Good explanation that should be supported with an image

Conclusion

Providing a safety system that is flexible which can be adapted to the requirements of the user is important. The reliability and durability of the system is also important. Therefore, using a safety scanner will increase the range of applications the safety system could be used in.

A Keyence SZ-V32N safety scanner is available for use in the current project. This can be combined with a Siemens S7 1200 to simulate a machine. The manual of the SZ-V safety scanners will be used to understand the input/output (I/O) of the scanner and its operation (www.keyence.co.uk, 2024).

It is possible that further research will need to be conducted throughout the design and implementation process.

Good argument for the choice of system

Specification

*Good spec of the system
requirements*

To create a successful system the following goals must be met:

- The scanner must communicate with the PLC
- The system must be able to warn a person they are entering a restricted zone
- When a person enters the zone the system must shut down the machine
- The machine should be able to be restarted when the person exits the zone
- Machine restart should be confirmed by an operator
- Protected zones should be able to be altered

Completion of these goals should create a system that can be easily adapted to work in differing environments.

Planning *Work plan*

To create the system, the manual of the SZ-V and the pinout diagrams of the S7 1200 must be read through and kept at hand while constructing the system.

By reading the SZ-V manual it is found that the black and white wires are called OSSD1 & 2. These are responsible for the signal sent by the scanner when something enters the restricted area. They are normally closed, therefore, the signal goes to 0 when the restricted area is entered. The software required for configuring the safety scanner can also be found in the manual along with an explanation of its functions. *Good detail here that should be under implementation stage*

Wire color and assigned function		
Wire color		Assigned function
	Brown	+24V DC
	Blue	0V
	Black	OSSD1
	White	OSSD2
	Gray	AUX output 1: Not used
	Gray/Black	AUX output 2: Not used
	Yellow	Input 1: Reset input or Laser OFF input
	Red	Input 2: EDM input
	Light blue	Input 3: Not used
	Light blue/Black	Input 4: Not used
	Yellow/Black	Input 5: Not used
	Red/Black	Input 6: Not used
	Orange	Input 7: Not used
	Orange/Black	Input 8: Not used
	Pink	Input 9: Not used
	Pink/Black	Input 10: Not used
	Green	AUX output 3: Not used
	Green/Black	AUX output 4: Not used

(www.keyence.co.uk, 2024)

To determine the pins available for I/O on the PLC the pinout diagram can be studied. This shows that the PLC has 12 24V DC inputs on the top of the PLC. The OSSD wires can be connected to 2 of the pins. The PLC also provides a 24V DC supply off the L+ and M pins. This can be used to power the safety scanner as it runs off 24V DC. To ensure the input pins function correctly the 1M pin can be grounded to the M pin. The PLC can send a signal to the machine controller or control the machine itself.

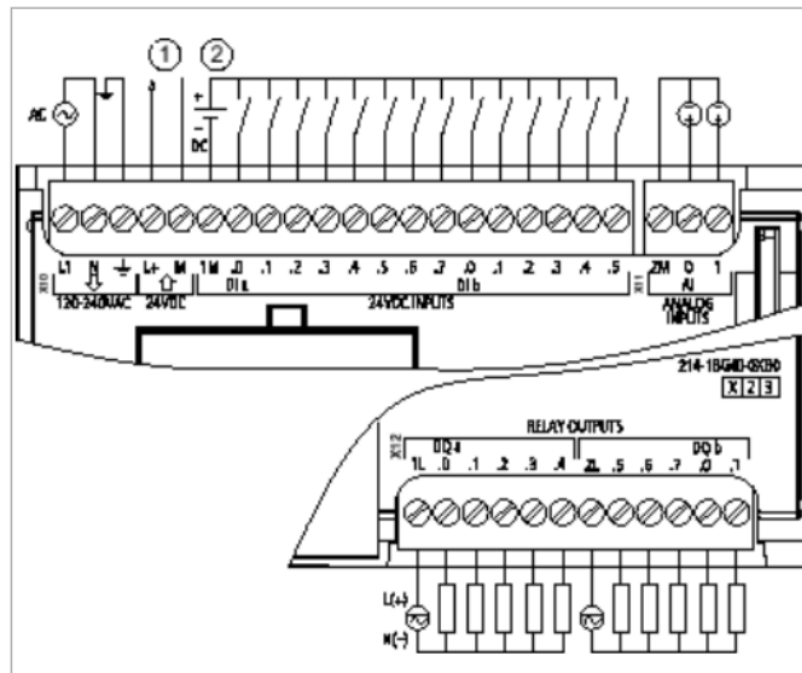
Good detail explained

The planning section should include a Gantt chart with detailed tasks breakdown.

CPU 1214C wiring diagrams

This is also implementation

Table: CPU 1214C AC/DC/Relay (6ES7214-1BG40-0XB0)



Good supporting diagram

(support.industry.siemens.com, 2021)

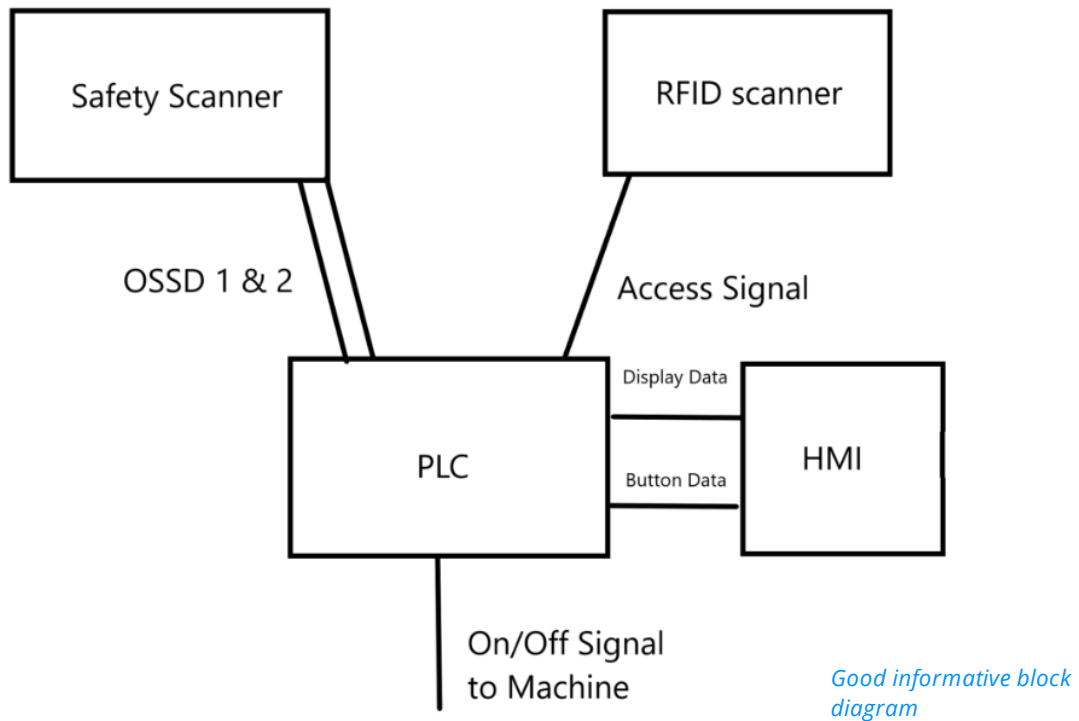
An aspect of a safety system that was overlooked in the specification is to ensure that the operator of the machine is qualified. Therefore, it is important to verify an operator's identity before starting the machine. A common method of securing a machine is to set a password and username. This would be a simple and effective solution, however, there are different methods that can be explored. An interesting solution is to use a radio-frequency identification (RFID) scanner and RFID cards. The scanner can read the RFID card's unique identity (UID) code to determine who is attempting to access the machine. Additional information can be stored on the card to provide additional information.

A method to accomplish this is to use an arduino and a peripheral RFID scanner device to read data from a scanned card and compare it to a saved list of UIDs with access to the machine. The arduino can then send an output to the PLC to determine whether the machine should be started.

To ensure the operator is aware of the state of the machine an interface is required. This can be done by using a human-machine interface (HMI) connected to the PLC. This will provide a graphical interface which can also be used as an input device.

The overall system can be explained in a diagram format.

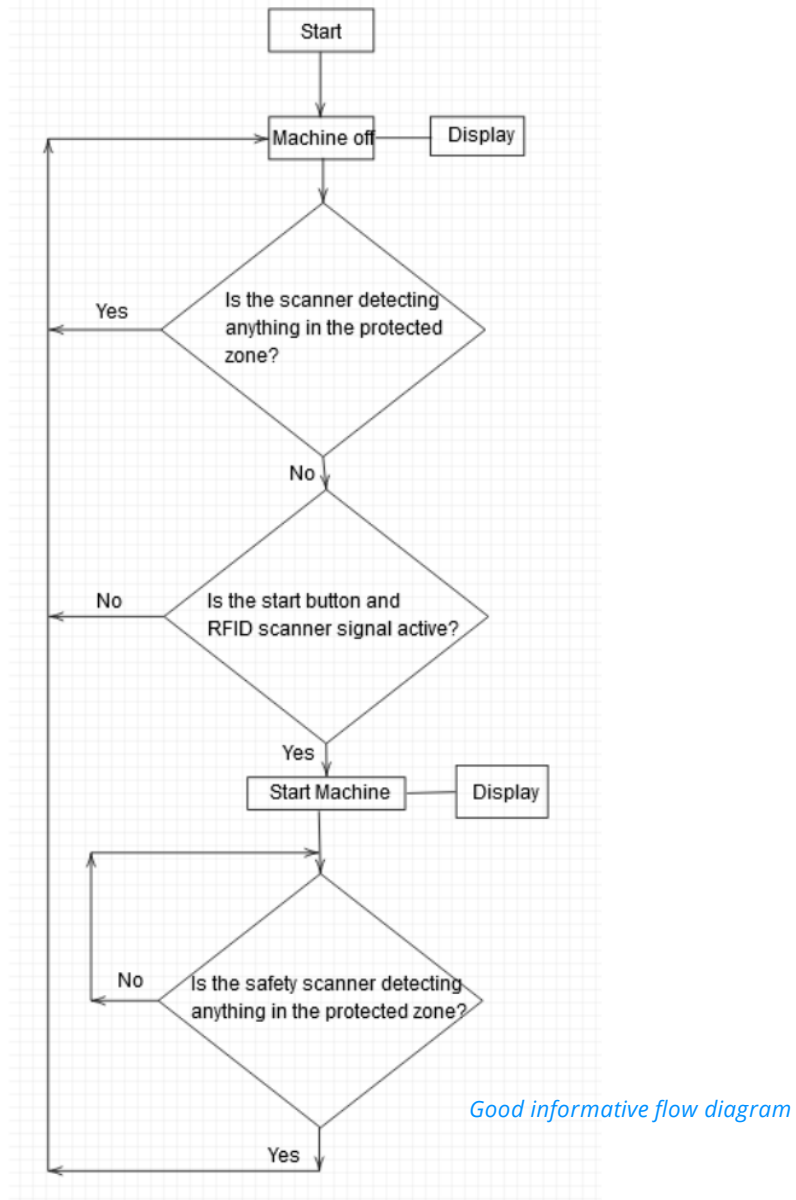
Good detailed explanation



Flow diagrams for each device can be drawn to create an outline for the underlying programs required.

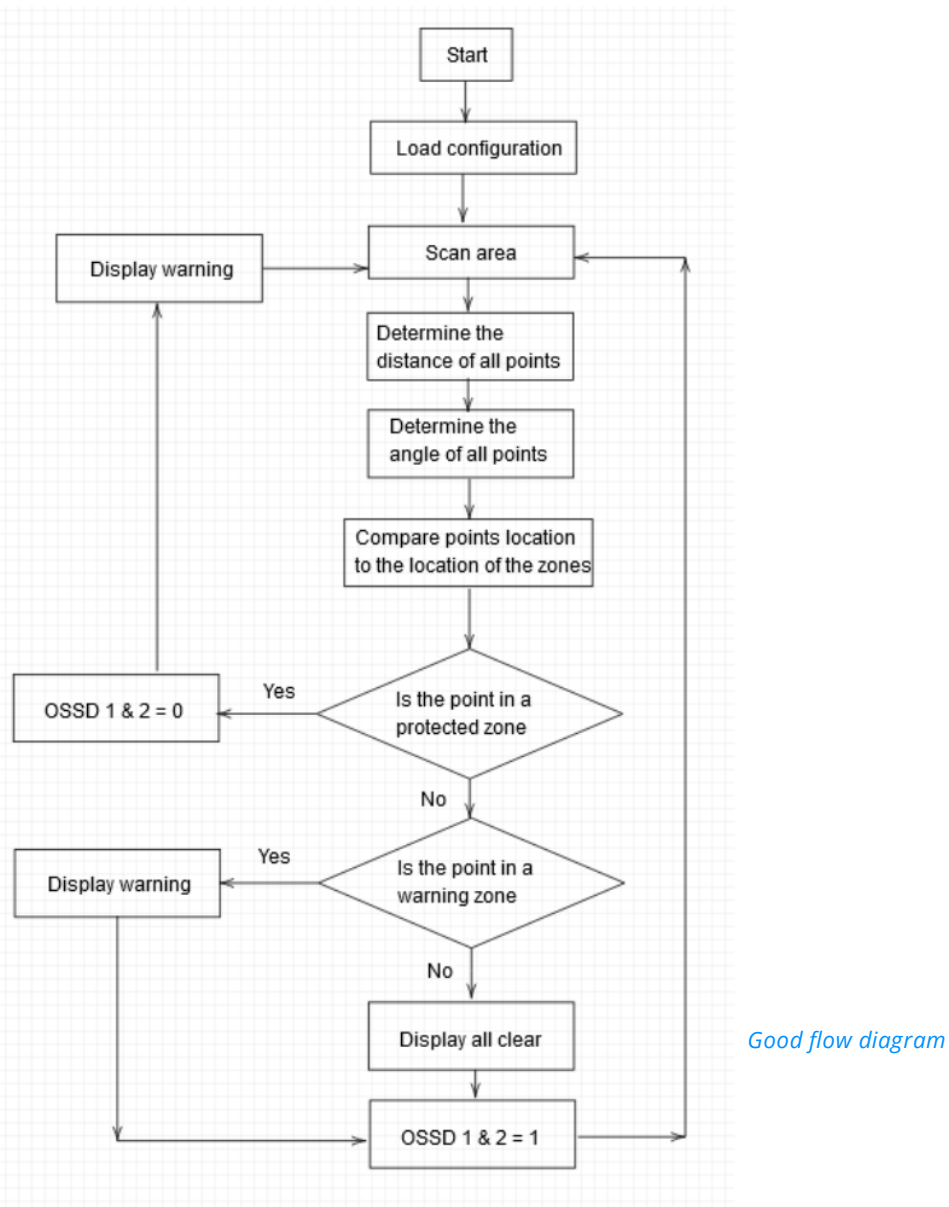
PLC

The programming behind the PLC should not be too complex. It will need to handle the inputs from the safety scanner and RFID scanner as well as controlling the HMI.



Safety Scanner

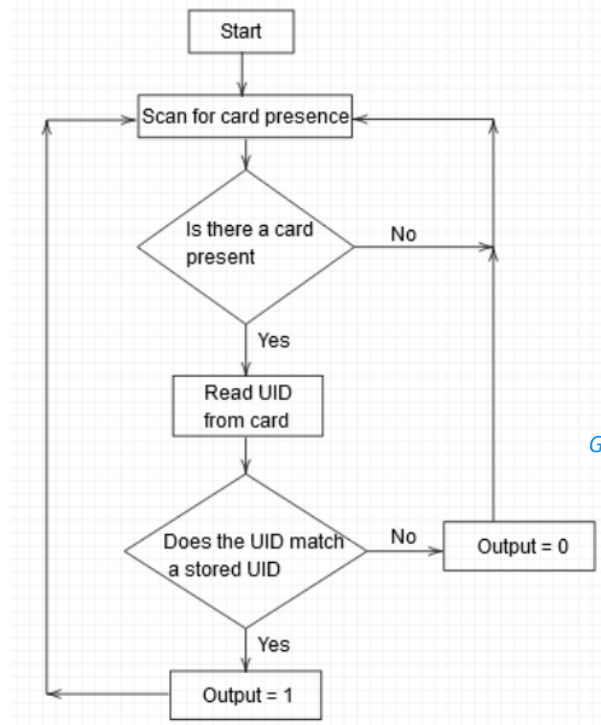
The safety scanner will not need to have any programming as the configurator handles that. However, the very basic principle of operation can be shown.



This is a generalisation of the functioning of the safety scanner. It will help determine how to use OSSD 1 and 2.

RFID Scanner

The flow chart will determine the ideal operation of the scanner.



Good work

Implementation

PLC and HMI

The software used to program the PLC is Siemens TIA Portal. To begin implementing the design of the system the easiest place to start is at the main control device of the system. In this case it is the PLC which controls the machines' state depending on the inputs. The machine must only be on when the OSSD signals are on, otherwise the protection zones will not work. To start the machine: the OSSD signals must be on; a signal from the RFID scanner must be on and the start button must be on. To stop the machine the OSSD signals could turn off or the stop button could be pressed.

Good functional explanation

The logic of the start condition is as follows:

START = OSSD1.OSSD2.StartButton.RFIDscanner

To continue running:

RUN = OSSD1 + OSSD2 + NotStopButton

To stop running:

NotRun = NotOSSD1 + NotOSSD2 + StopButton

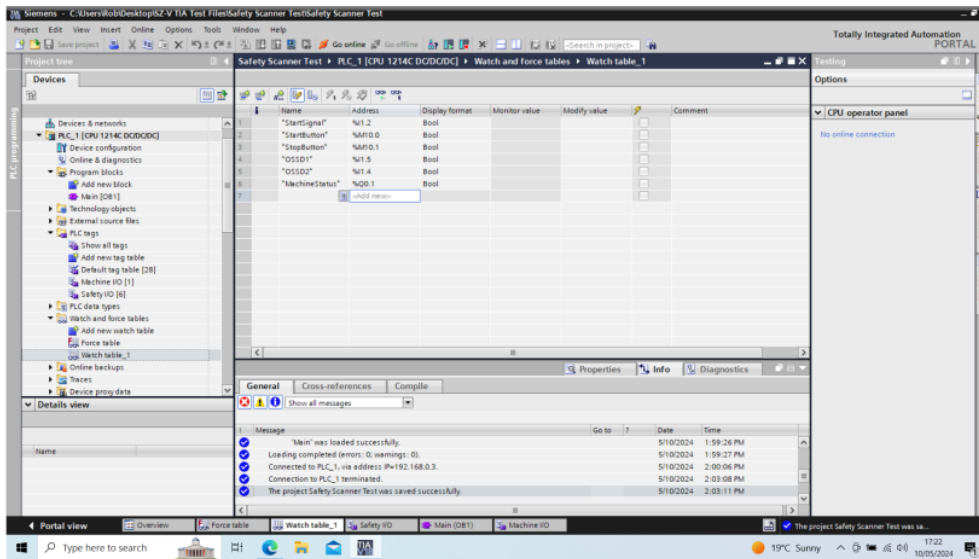
Since the logic is simple, the easiest method to implement it is in a ladder diagram format. To begin the implementation the I/O pins must be determined.

Input	Address
Start Signal	%I1.2
Start Button	%M10.0
OSSD1	%I1.5
OSSD2	%I1.4
Stop Button	%M10.1

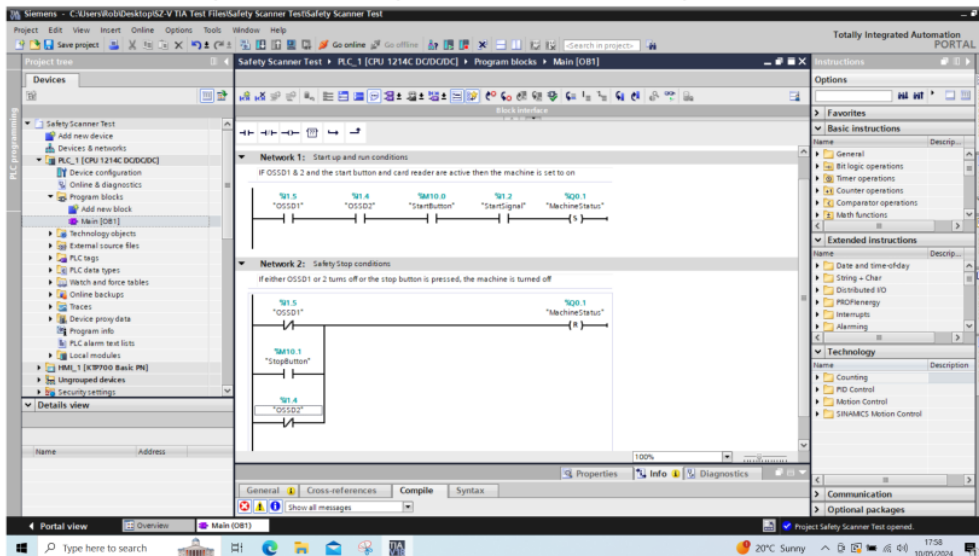
Output	Address
MachineStatus	%Q0.1

Excellent work with the investigation of hardware requirements

The I/O and their addresses can be added into the tag tables.



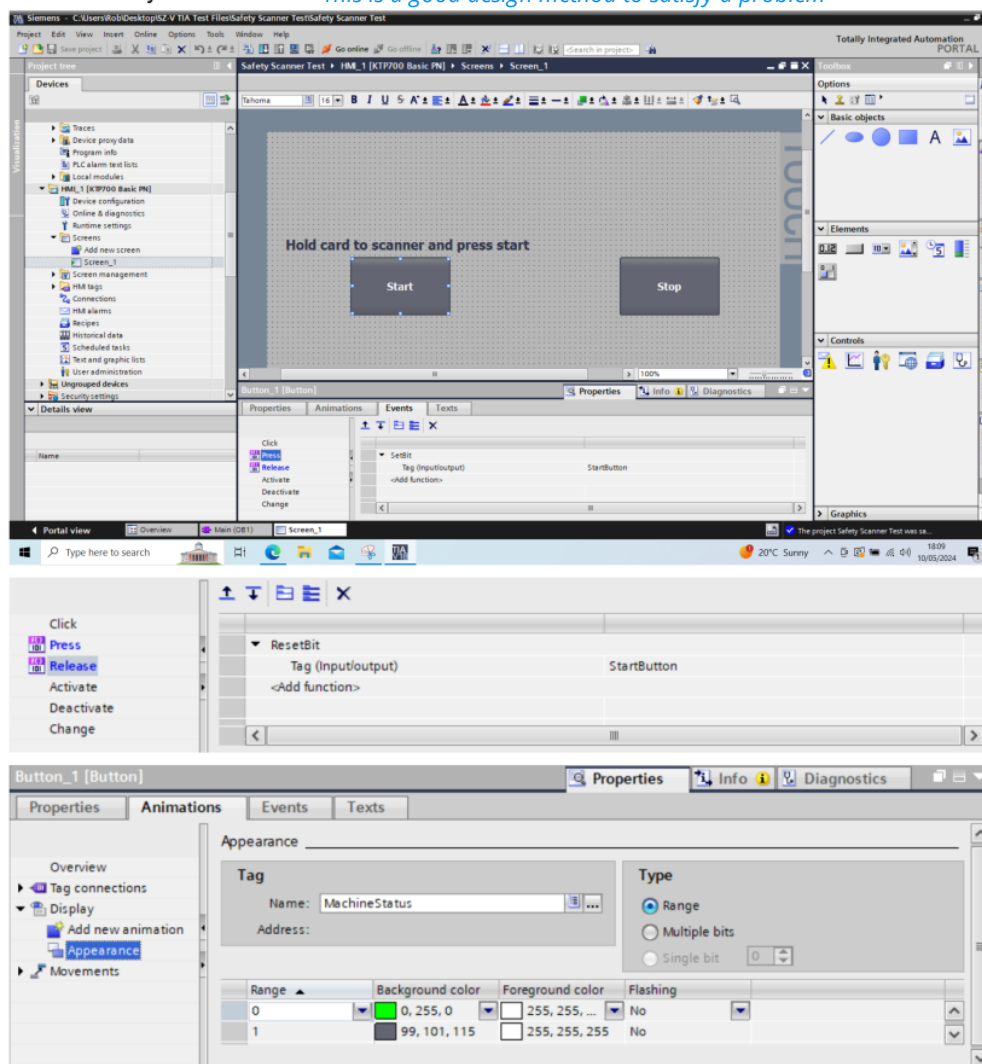
Within the main program block the logic of the PLC can be configured.



Ladder programming is read as a circuit. The program consists of the state of the contacts for each input and output. Since OSSD1 and 2 are normally closed, the logic needs to consider that.

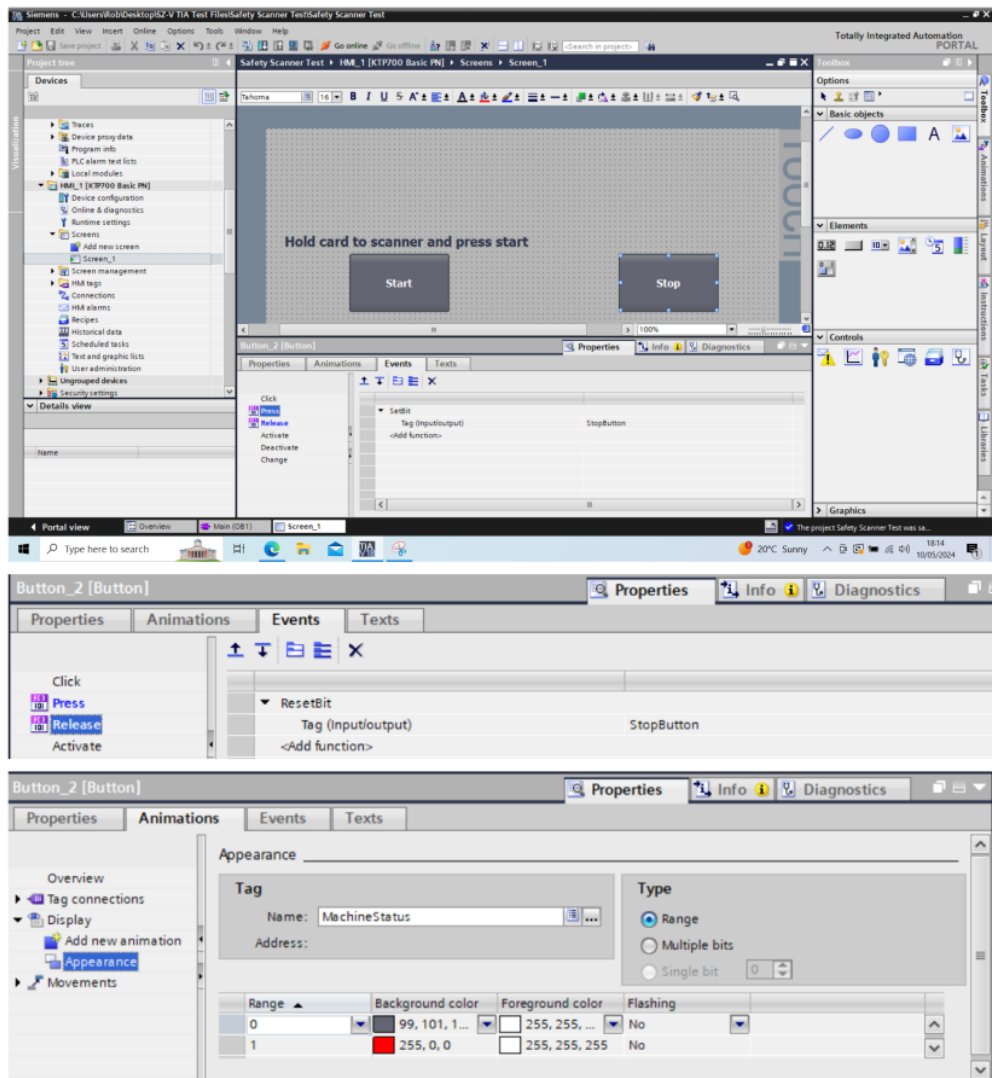
Good implementation of PLC program with logic sequence

The HMI is also configured from the same file as the PLC is. The HMI only needs to display a start button, a stop button and a method of telling whether the machine is running or not. The simplest way to do this is to have two labelled buttons which light up when they can be pressed. The start button will light up when the machine is not running, and the stop button will light up when the machine is running. It may also help to colour code the buttons to further convey their use. *This is a good design method to satisfy a problem*



The start button sets the corresponding memory bit to on when pressed and off when released. The colour of the button changes to a bright green when the machine is off and grey when the machine is on. The button can be pressed when the machine is off and the button is green.

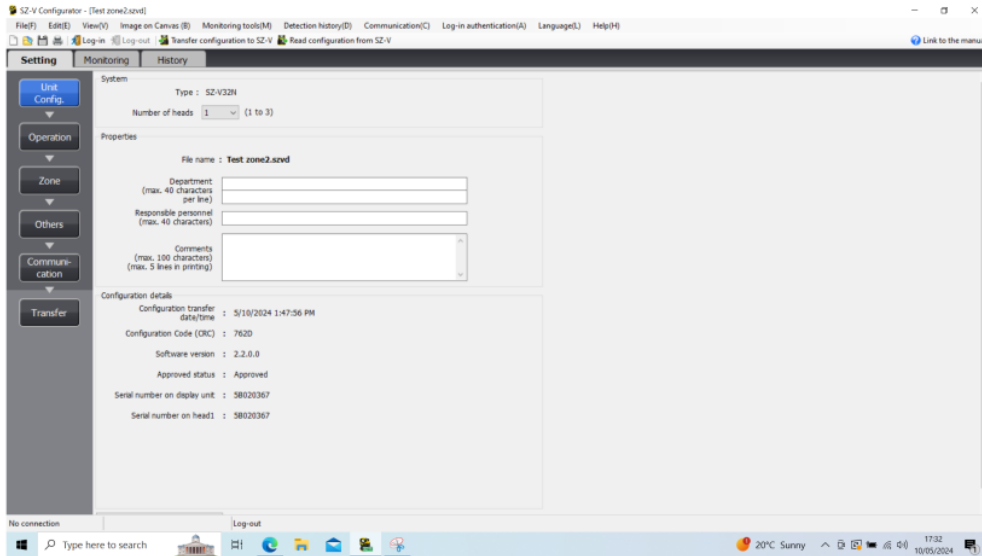
Good work



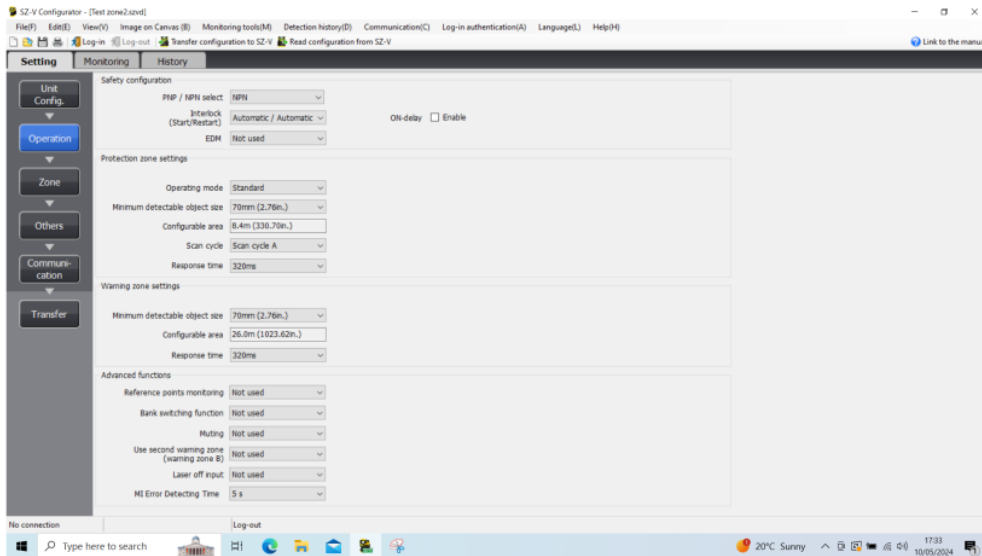
The stop button is set up similarly to the start button. However, it controls its own memory bit and turns red when the machine is running to signal that the button can be pressed to turn it off.

Safety Scanner

To configure the safety scanner the Keyence safety device configurator must be used. The configurator must be started in the SZ-V32N mode as this is the model of scanner being used.

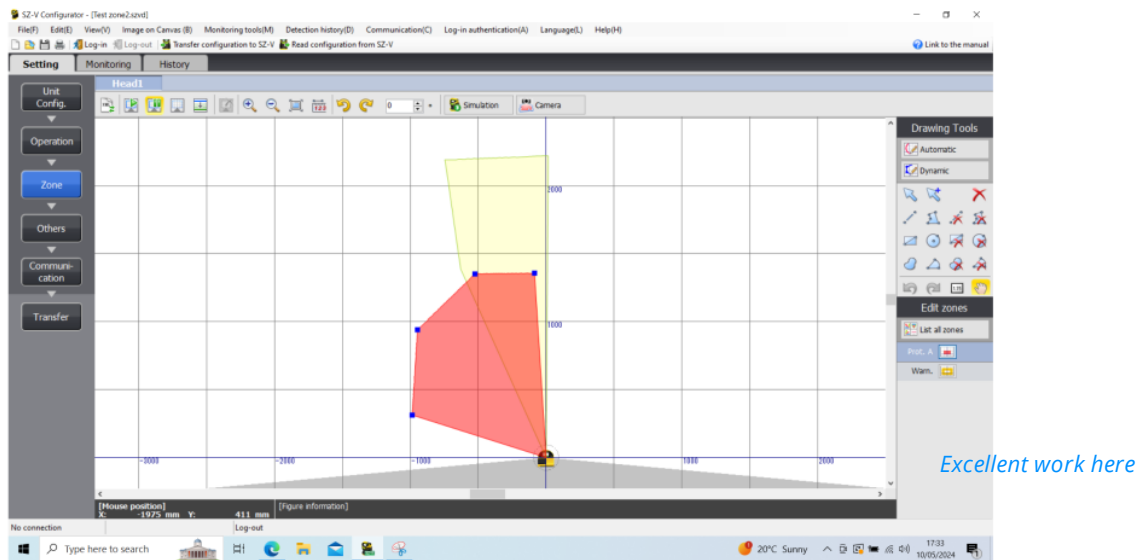


Since there is only one scanner the number of heads is set to 1. The information is not filled out as this is only a test configuration.

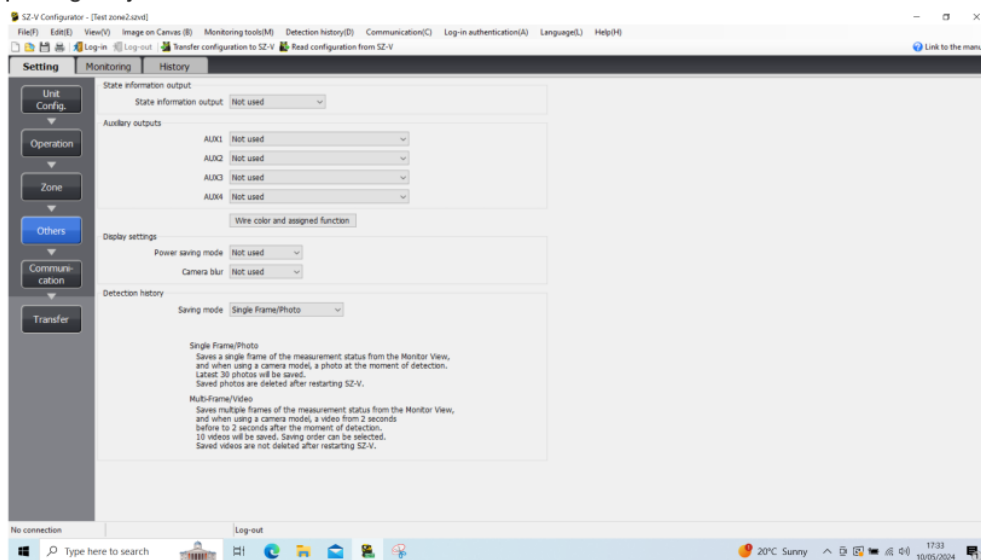


The transistors are set to NPN and none of the settings are changed as the scanner is being used in its simplest use case.

Good configuration evidence

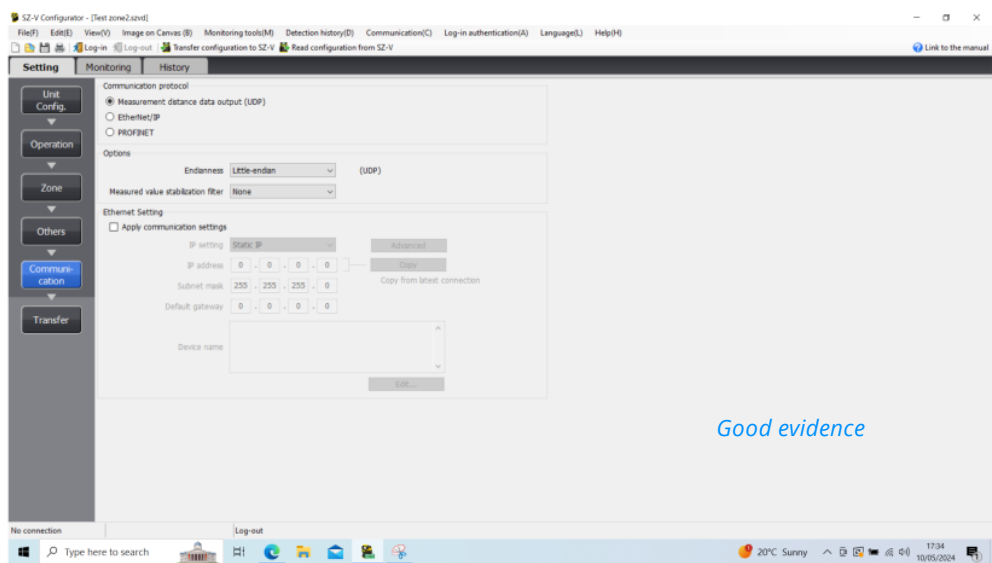


The warning and protection zone are drawn. This is an example of it protecting a passageway with a machine at the same end as the scanner.



Only the OSSD outputs are being used, so none of the auxiliary outputs are required. The scanner is set to take an image when the protection zone is breached. This helps to monitor the areas' activity.

Good explanation

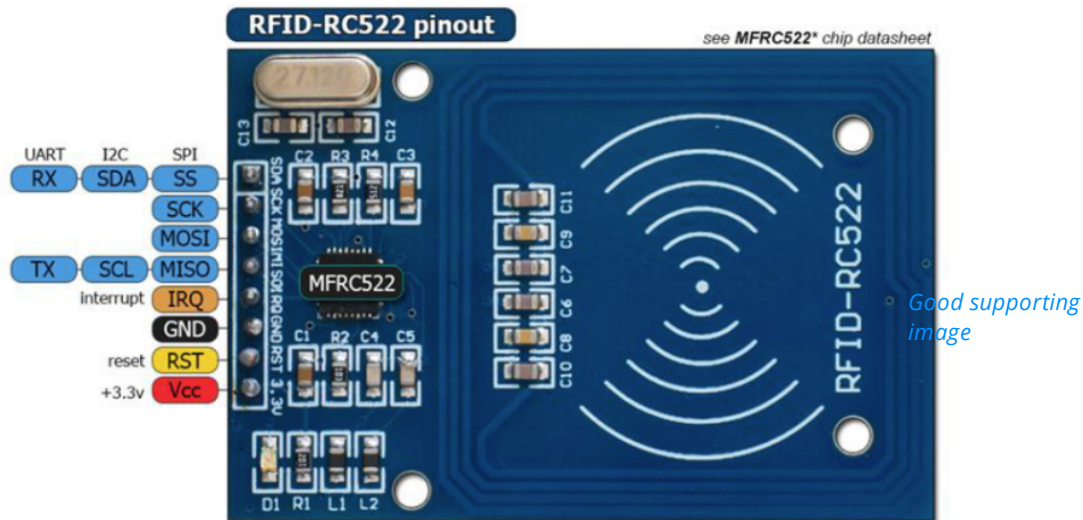


Good evidence

Since the scanner is not being connected to a network no ethernet settings are required. Therefore, the standard communication protocol is used.

RFID scanner

Since the controller for the scanner is an arduino the standard RFID scanner for an arduino can be used. This is an RFID_RC522 scanner, and the chip used within the device is an MFRC522 (Handson Technology). The pinout diagram of the device is used to connect the arduino to the scanner.



Correct citation

A library is also linked, which will simplify the reading of the data (Balboa.M, 2024). Within the file, there are examples to work from which demonstrate how the library works. By understanding the examples the program can be made:

```
1 #include <MFRC522.h> // Include the library to interface with the RFID scanner
2 #include <SPI.h> // Include the library for SPI communications (required for Arduino to RFID comms)
3
4 #define RST_PIN 9 // Define the pin connected to the reset (RST) pin of the RFID module
5 #define SS_PIN 10 // Define the pin connected to the slave select (SS) pin of the RFID module
6 #define Access_PIN 2 // Define the pin connected to the Access Output
```

The required libraries are included in the program. The reset and the slave select (activate/deactivate device) pins are defined for the RFID module. The pin being used for the output signal is also defined.

```
9 MFRC522 RFIDscanner(SS_PIN, RST_PIN); // Create an instance of the MFRC522 class
10
11 MFRC522::MIFARE_Key keyA; // Sets the MIFARE key for key A
12 MFRC522::MIFARE_Key keyB; // Likewise for key B
13 MFRC522::StatusCode status; // Sets the status variable to the status code of the RFID
14 byte block = 0; // Selects the block to read/write from/to
15 byte buffer[18]; // Buffer to save space for data storage
16 byte UID[4]; // Variable to save the input UID in
17 byte ValidUID[4] = {208,70,122,66}; // Sets the UID required for access
18 int flag = 0; // Access flag
```

The RFID scanner is initiated and variables are set. The default keys are used since the cards are unmodified. The UID is in block 0 in sector 0 at byte 0 (NXP, 2018). The UID with access to the machine is 208 70 122 66.

Good explanation

```

20 void setup() {
21   Serial.begin(9600); // Begins communications between computer and Arduino, specifying data transfer speed (baud rate)
22   SPI.begin(); // Starts the SPI communications between Arduino and MFRC522
23   RFIDscanner.PCD_Init(); // Initializes the RFID scanner
24   pinMode(Access_PIN, OUTPUT); //Sets Access_PIN as an output
25 }

```

The setup function configures the communications between the arduino and RFID scanner. It also starts the RFID scanner and communications. The pin for the output signal is set as an output.

```

27 void loop() {
28   if (!RFIDscanner.PICC_IsNewCardPresent()) { // If a PICC card is not detected return to top
29     return;
30   }
31
32   if (!RFIDscanner.PICC_ReadCardSerial()) { // Return to top if card cannot be read
33     return;
34   }
35
36   for (byte i = 0; i < RFIDscanner.uid.size; i++) { // Repeats for the number of bytes used in the UID
37     UID[i] = (RFIDscanner.uid.uidByte[i]); // Sets the UID storage array at pointer i to the read UID at pointer i
38   }

```

The loop function continuously loops as long as the arduino is powered. If there is no card present or the card cannot be read, the loop resets. If there is a card present that can be read, the UID is read and transferred into the UID array.

```

41   flag = 0; // Defaults the access flag to 0
42   for (byte i = 0; i < 4; i++) { // Repeats 5 times
43     if (UID[i] == ValidUID[i]) { // If the read UID is equal to the stored value
44       flag = 1; // If equal flag is set to 1
45     } else {
46       flag = 0; // If different flag is set to 0
47     }
48   }
49
50   if (flag == 1) { // If the flag is 1
51     digitalWrite(Access_PIN, HIGH); // Turns pin 2 on
52     Serial.println("Access Granted"); // Prints
53   } else { // If flag does not equal 1
54     digitalWrite(Access_PIN, LOW); // Turns pin off
55     Serial.println("Access Denied"); // Prints
56   }
57
58   delay(2000); // Delay of 2 seconds
59   digitalWrite(Access_PIN, LOW); // Resets pin to off
60
61
62 }

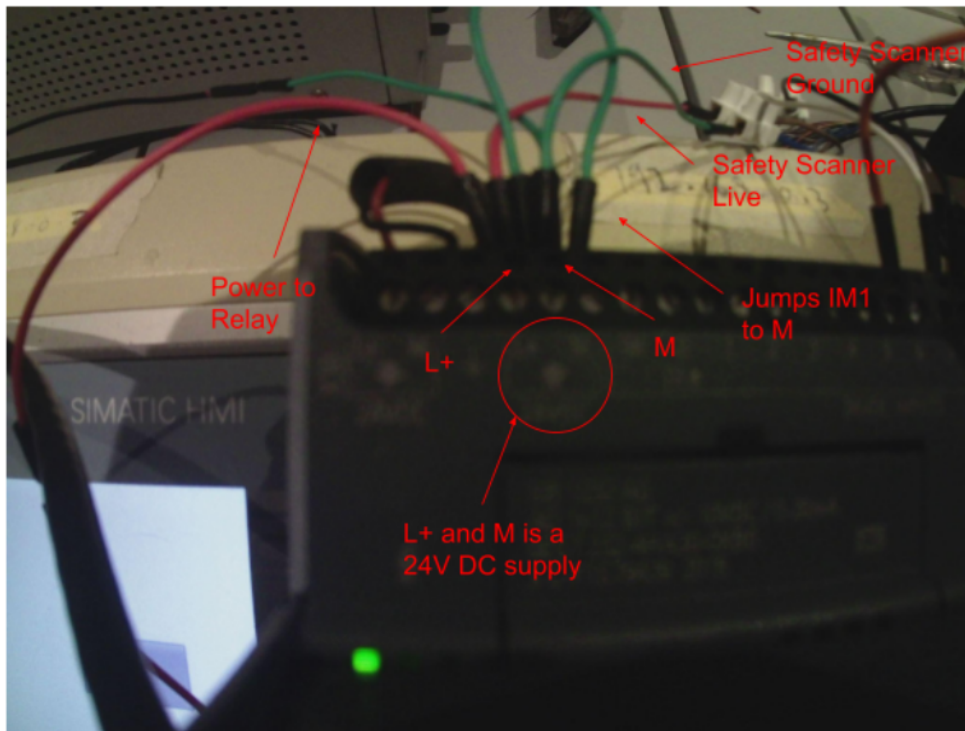
```

If the read UID matches the stored UID the program turns on the output pin, delays, then turns it off again. If it does not match, the pin stays off. The loop returns to the top.

Good work

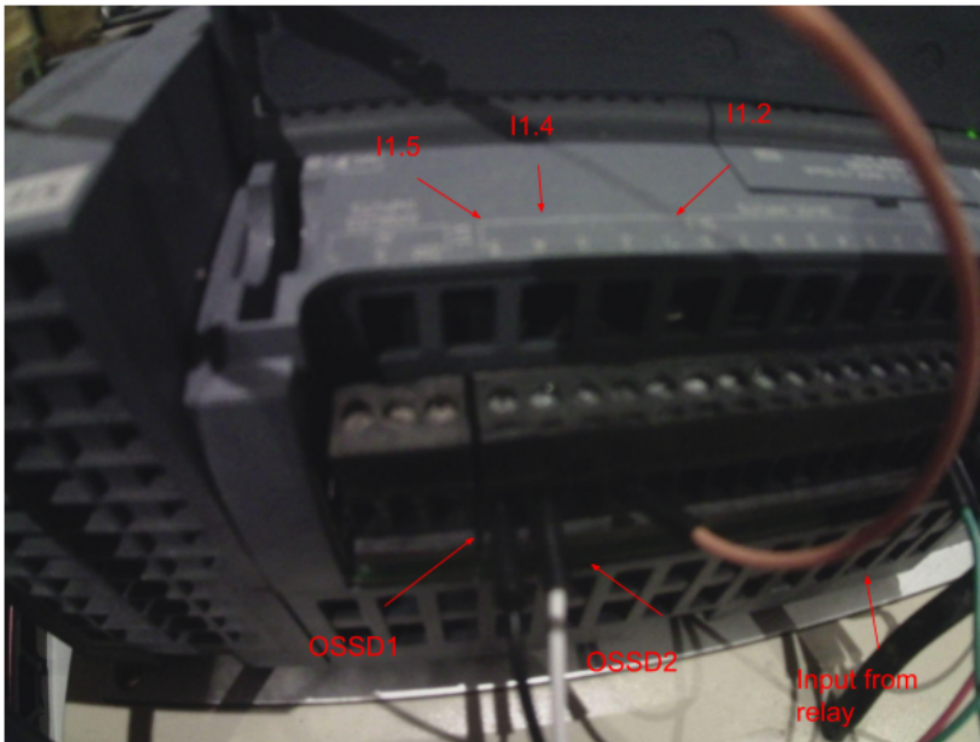
Hardware Implementation

The final system can be assembled. This involves powering the scanner using the onboard 24V DC supply from the PLC.



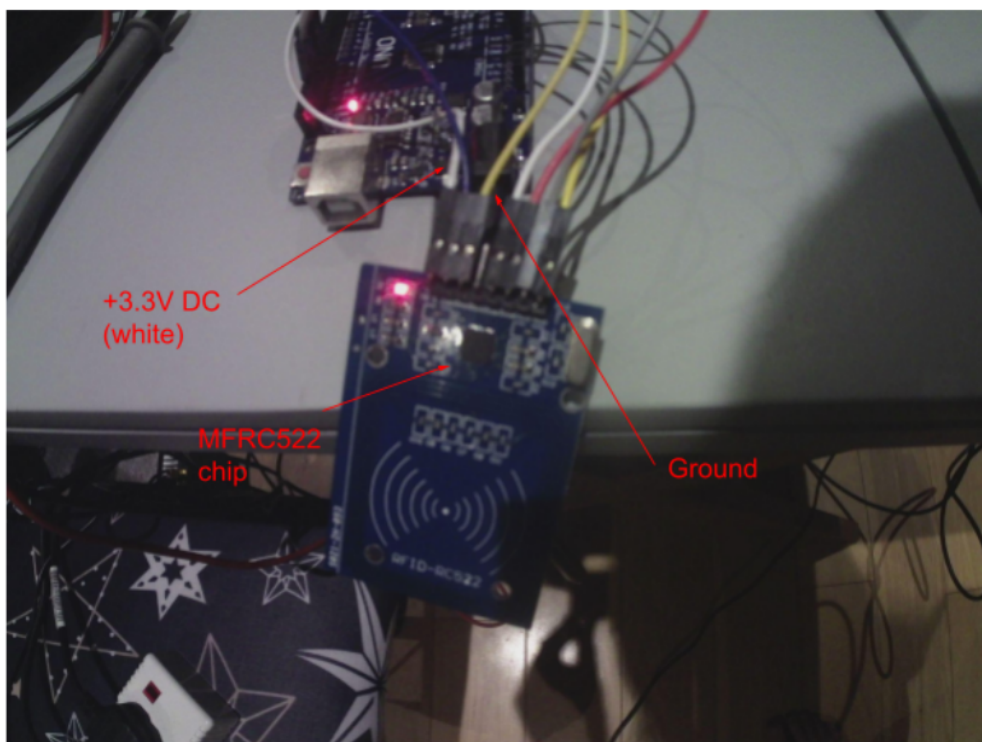
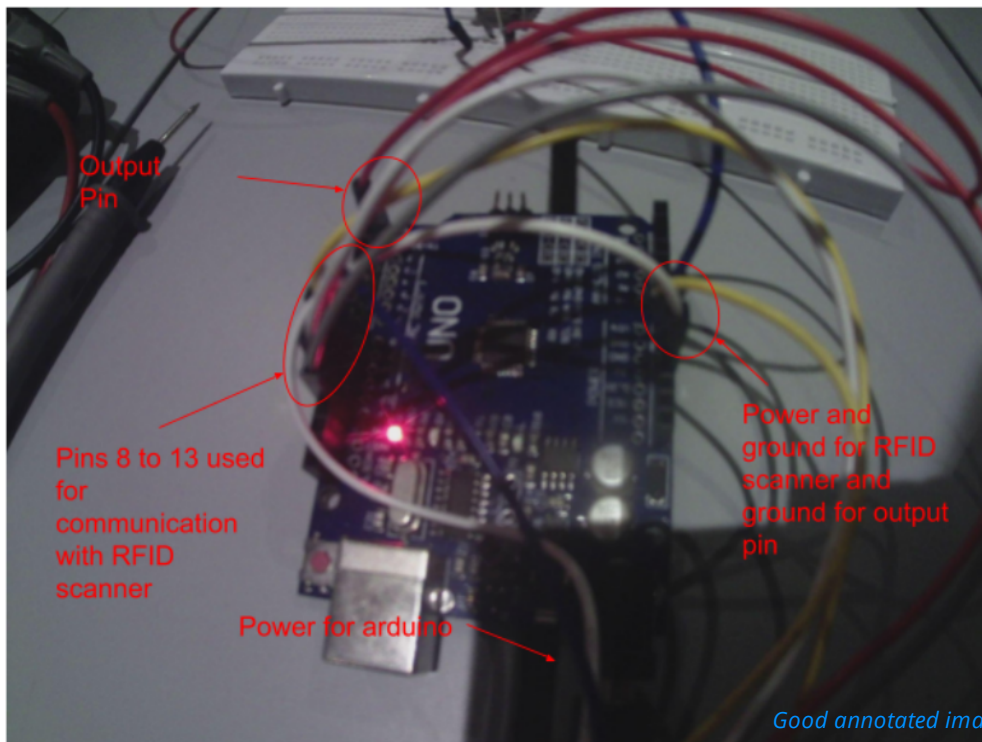
The live and ground (red and green, respectively) from the PLC supply are connected to the safety scanner via the brown and blue wires. The jump from IM1 to M provides a common ground for the inputs and the supply to the scanner and relay.

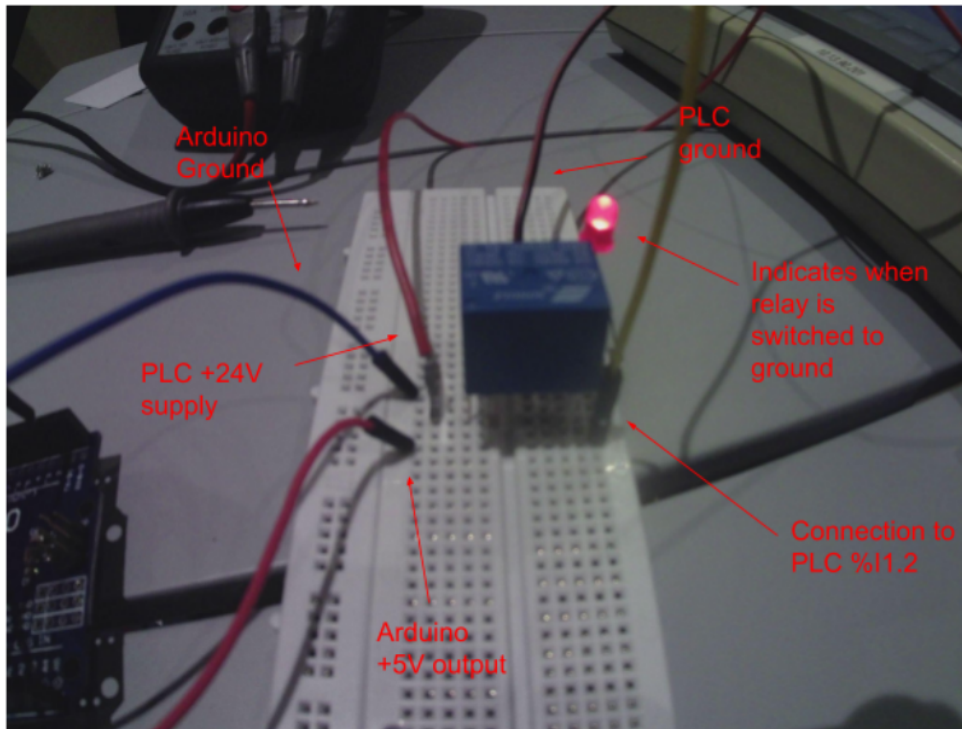
Good annotated image with explanation



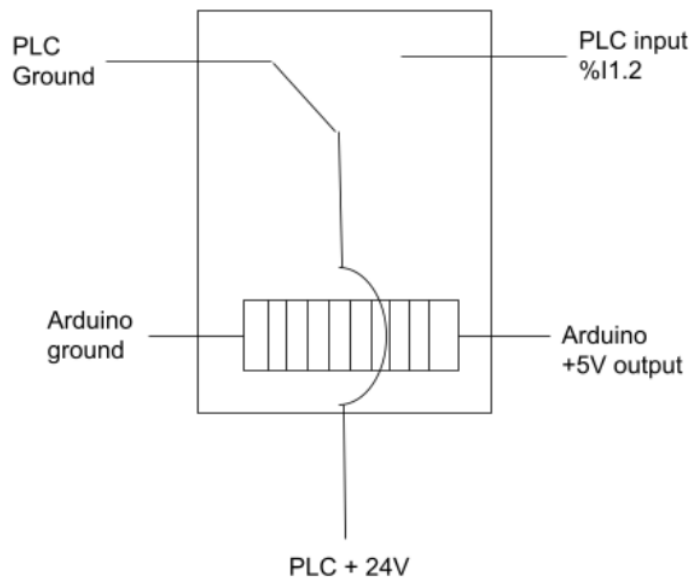
OSSD1 and 2 are connected to the addresses stated in the I/O table as well as the start signal from the arduino.

Good annotated image

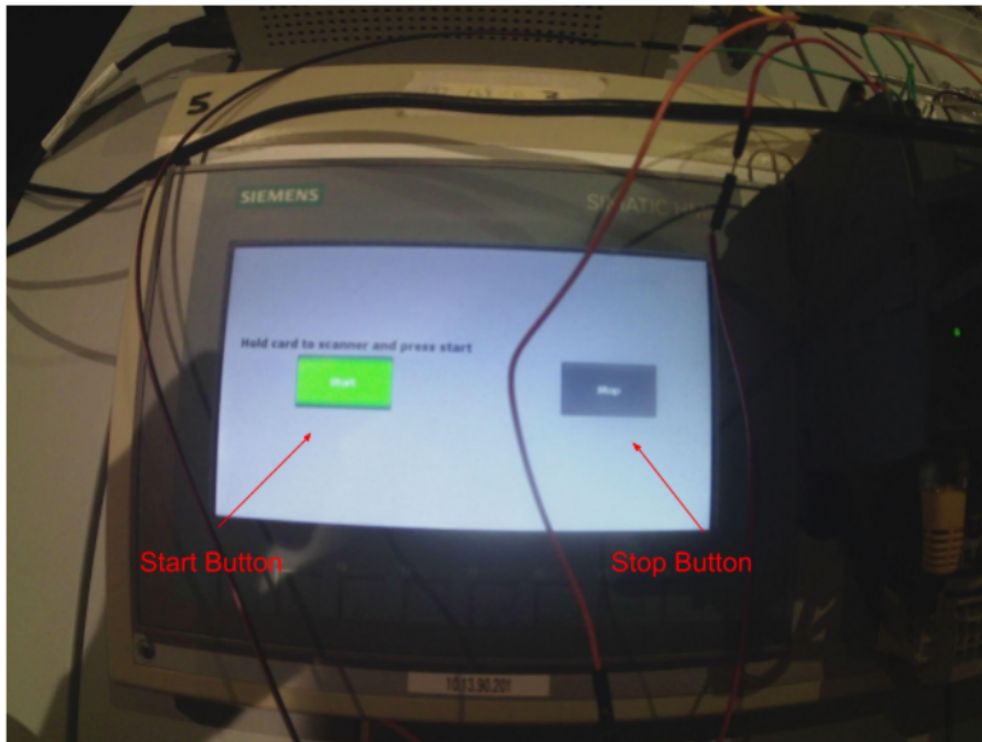




Good images



The relay's coil is connected to the output signal pin of the arduino and the ground of the arduino. When the coil is powered, the 24V from the PLC is switched from ground to the input pin at the address %I1.2.



Good
evidence of
HMI



A demonstration of the system can be found at
https://www.youtube.com/watch?v=2r8Og5_zG1w (Utting.W, 2024).

Testing

Good use of test table

Test	Expected Result	Result	Fix	Proof
Use RFID scanner and button to turn on machine	Machine turns on	Machine turns on		https://www.youtube.com/watch?v=OGE68VSI04o
Try to turn on machine with only start button	Machine doesn't turn on	Machine doesn't turn on		https://www.youtube.com/watch?v=OGE68VSI04o
Try to start machine with only RFID card	Machine doesn't turn on	Machine doesn't turn on		https://www.youtube.com/watch?v=OGE68VSI04o
Try to turn machine on while standing in protected zone	Machine doesn't turn on	Machine doesn't turn on		https://www.youtube.com/watch?v=OGE68VSI04o
Try to turn on machine while in warning zone	Machine turns on	Machine turns on		https://www.youtube.com/watch?v=OGE68VSI04o
Try to alter scanner position	Scanners' zones will not function as intended	Scanners' zones will not function as intended	Set a reference point in the software or fix to a sturdy bracket	https://www.youtube.com/watch?v=OGE68VSI04o
Try to change scanner zones from scanner head	Changing zones is password protected	Changing zones is password protected		https://www.youtube.com/watch?v=OGE68VSI04o
Bypass RFID scanner	RFID scanner is now obsolete	RFID scanner is now obsolete	Secure the scanners' hardware and wiring	https://www.youtube.com/watch?v=OGE68VSI04o
Present incorrect card to RFID scanner	No signal is sent to the PLC	No signal is sent to the PLC		https://www.youtube.com/watch?v=OGE68VSI04o
Leave object in warning zone then step into	Machine turns off	Machine turns off		https://www.youtube.com/watch?v=OGE68VSI04o

protected zone				O4o
Throw object into protected zone	Machine turns off	The scan rate of the scanner is not fast enough to detect the object	Increase the scan rate of the scanner	https://www.youtube.com/watch?v=OGE68VSI04o
Disconnect OSSD1	Machine does not turn on	System functions as normal	Change the normally closed contacts to normally open	https://www.youtube.com/watch?v=OGE68VSI04o
Disconnect OSSD2	Machine does not turn on	System functions as normal	Change the normally closed contacts to normally open	https://www.youtube.com/watch?v=OGE68VSI04o
Change protection zone	Zone can be changed easily	Zone can be easily changed in the configurator		https://www.youtube.com/watch?v=OGE68VSI04o
Change warning zone	Zone can be changed easily	Zone can be easily changed in the configurator		https://www.youtube.com/watch?v=OGE68VSI04o

Good tests carried out, but cannot have youtube videos as test evidence.

Conclusions and Recommendations

The final system achieves all objectives stated in the specification. The system warns a person that they are entering a restricted area via an orange light and shuts down the output to a machine once the area is breached. To restart the machine an operator must provide a form of identification and be out of the restricted area while pressing the start button.

Good point that adds security to the hazardous area

The security aspects of restarting the machine could be improved. When setting the access UID required, the data could be encrypted to prevent unauthorised access to the sensitive information. A second layer of security could be added by requiring the operator to input a pin code. The pin code could be stored on the RFID card as well as entering it into the program to ensure the correct person is using the machinery. To protect against anyone trying to bypass the RFID scanner the device and its components should be safely stored within a case. The output wires should also be protected.

Good point

Another improvement to the system would be to set a reference point within the configuration file of the safety scanner. This would ensure that the protection and warning zone are set in the correct location if the scanner is knocked into a slightly different orientation. Fixing the scanner to a bracket would also help to keep the zones in the same place. If there is a risk of fast moving objects entering the area then the scan rate will need to be increased. However, increasing the scan rate increases the minimum size of objects the scanner can detect. Having the system remain functioning when one of the OSSD wires is disconnected could be an advantage or a disadvantage depending on the environment. If the scanner is in an environment where the wires may be damaged the backup of having two wires that are independent of each other will be an advantage. The scanner may be in an environment where damage to either wire suggests that the machine has malfunctioned, in that case the machine should only run when both wires are functioning.

Good point and recommendation

The decision to use a safety scanner over a light curtain is debatable. For maximum flexibility a safety scanner is the best choice. However, if the application is to protect an entrance to a hazardous zone a light curtain would be cheaper and more effective than a laser scanner. In the context of this project, where the aim was to protect an area instead of an entrance, the safety scanner is the most effective solution. It was also interesting to research and develop a system using the technology of the scanner.

A good argument for choosing the scanner

Citations

GOV.UK (1974). *Health and Safety at Work etc. Act 1974*. [online] Legislation.gov.uk. Available at: <https://www.legislation.gov.uk/ukpga/1974/37/section/2>. Accessed [09 May, 2024].

OSHA.gov (n.d.). *Safety Committee Handout*. [online] www.osha.gov. Available at: <https://www.osha.gov/sites/default/files/2021-07/Safety%20Committee%20Handout%20%20Mechanical%20Hazards.pdf>. Accessed [09 May, 2024].

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Good number of sources investigated

HNC Project 2111222

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

65/100

PAGE 1

PAGE 2

Text Comment. Table of contents needs to be more detailed

Text Comment. List of figures should be included

PAGE 3

Text Comment. Intro includes good points

PAGE 4

Text Comment. Relevant points made

Text Comment. Correctly cited

Text Comment. Correct citation

Text Comment. Very good points made relevant to the objective of the project

Text Comment. This could be considered as an alternative solution and should include a diagram to support the explanation.

Text Comment. Correct citation

Text Comment. Good point here

Text Comment. Good explanation that should be supported with an image

PAGE 5

Text Comment. Good argument for the choice of system

PAGE 6

Text Comment. Good spec of the system requirements

PAGE 7

Text Comment. Work plan

Text Comment. Good detail here that should be under implementation stage

Text Comment. The planning section should include a Gantt chart with detailed tasks breakdown.

Text Comment. Good detail explained

PAGE 8

Text Comment. This is also implementation

Text Comment. Good supporting diagram

Text Comment. Good detailed explanation

PAGE 9

Text Comment. Good informative block diagram

PAGE 10

Text Comment. Good informative flow diagram

PAGE 11

Text Comment. Good flow diagram

PAGE 12

Text Comment. Good work

PAGE 13

Text Comment. Good functional explanation

Text Comment. Excellent work with the investigation of hardware requirements

PAGE 14

Text Comment. Good implementation of PLC program with logic sequence

PAGE 15

Text Comment. This is a good design method to satisfy a problem

Text Comment. Good work

PAGE 16

PAGE 17

Text Comment. Good configuration evidence

PAGE 18

Text Comment. Excellent work here

Text Comment. Good explanation

PAGE 19

Text Comment. Good evidence

PAGE 20

Text Comment. Good supporting image

Text Comment. Correct citation

Text Comment. Good explanation

PAGE 21

Text Comment. Good work

PAGE 22

Text Comment. Good annotated image with explanation

PAGE 23

Text Comment. Good annotated image

PAGE 24

Text Comment. Good annotated images

PAGE 25

Text Comment. Good images

PAGE 26

Text Comment. Good evidence of HMI

PAGE 27

PAGE 28

Text Comment. Good use of test table

PAGE 29

Text Comment. Good tests carried out, but cannot have youtube videos as test evidence.

PAGE 30

Text Comment. Good point that adds security to the hazardous area

Text Comment. Good point

Text Comment. Good point and recommendation

Text Comment. A good argument for choosing the scanner

PAGE 31

Text Comment. Good number of sources investigated

GRADING FORM: CSG-RUBIC

WILLIAM UTTING

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RESEARCH-INFORMED LITERATURE



There is extensive researched carried out for the development of the project. The two solutions should have been identified as solutions in the report.
Good number of souces used.

14/20

KNOWLEDGE AND UNDERSTANDING



Spec is identified as functinallty of the scanning system. The additionof the RFID identifier enhanced the system. A wide range of technologies have been considered and investigated with a high level of detial and complexity. This includes both hardware and software. The headings in the report shuld identfiy the solutions.

12/20

ANALYSIS



Good test results in test table, however, you cannot use youtube videos as test evidence.
Images on the scanner being activated should be used as part of the evidence.
Good conclusion and recommendations.

13/20

PRACTICAL APPLICATION AND DEP.



The plan is only for the implementation . There is no project plan with Gantt chart or work breakdown structure.
Practical implementation is highly detailed with very good explanations. A wide range of technologies have been integrated to build the system.
A high level of development initiative has been demonstrated.

18/20

SKILLS FOR PROFESSIONAL PRAC.



Report lacked a detailed table of contents and list of figures. The structure should be more efficiently presented.

8/15