

TUTORIAL: how to configure and set up a system for a robotic cell

Access Detection and Restart Prevention inside the cell

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Revision	Author	Date	Notes
v01	I. Paderno	21/07/2022	Initial version
v02	B. Treachi	05/08/2022	Small changes

Revision	Approved by	Date
v01	TS&CS	04/08/2022

1. Introduction

The scope of this document is to describe how to configure an Inxpect SRE 200 Series system to protect a robotic cell for both Access Detection and Restart Prevention safety functions.

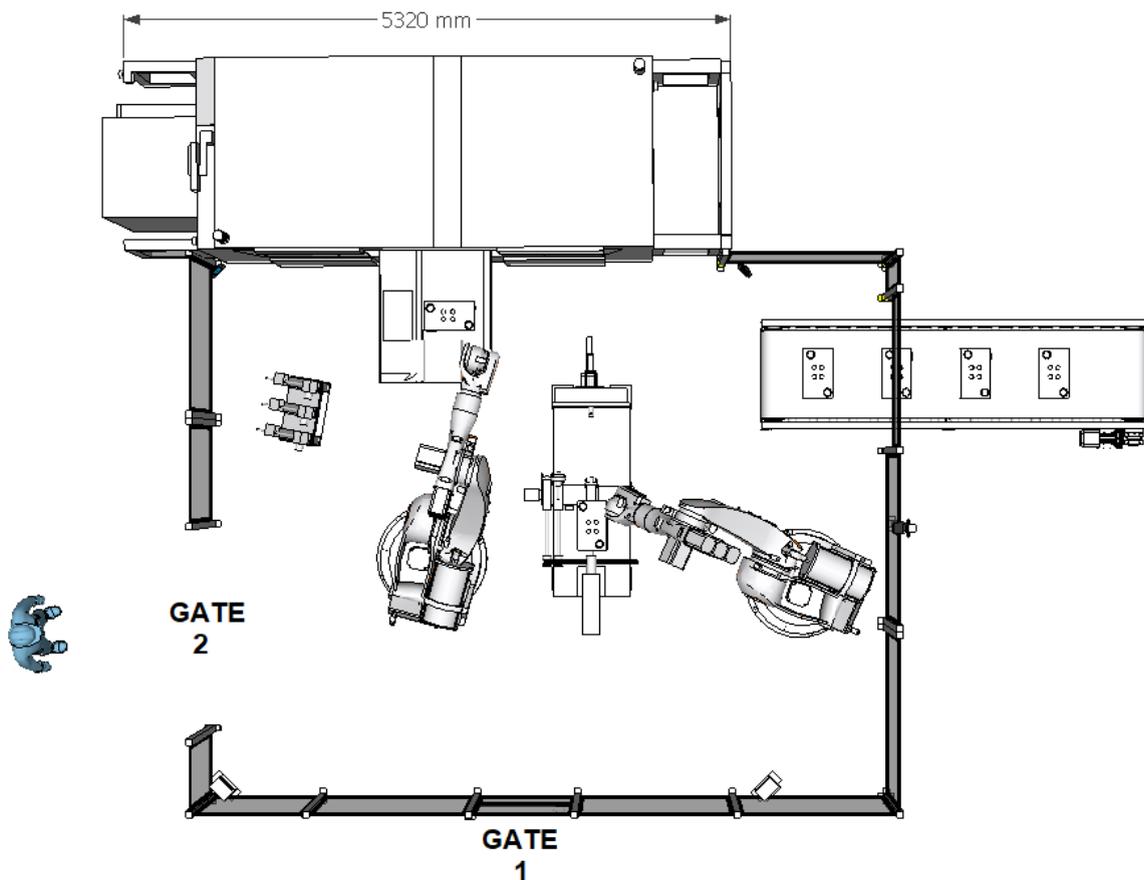
Note: this is just an example that should be used with the goal to understand how to configure an Inxpect device.

The analysis is elaborated only from the Inxpect System point of view. Other additional safety equipment could be required and could work in parallel to the Inxpect System (for instance GATE 1 should have an interlock device that stops the robot inside the cell).

1.1 Objectives

Given the hypothetical robotic cell in the below picture, the objectives are the following:

- 1) to detect the access of an operator through the open GATE 2 (Access Detection)
- 2) to detect the presence of an operator inside the cell before restarting the robots (Restart Prevention)



2. Radar position

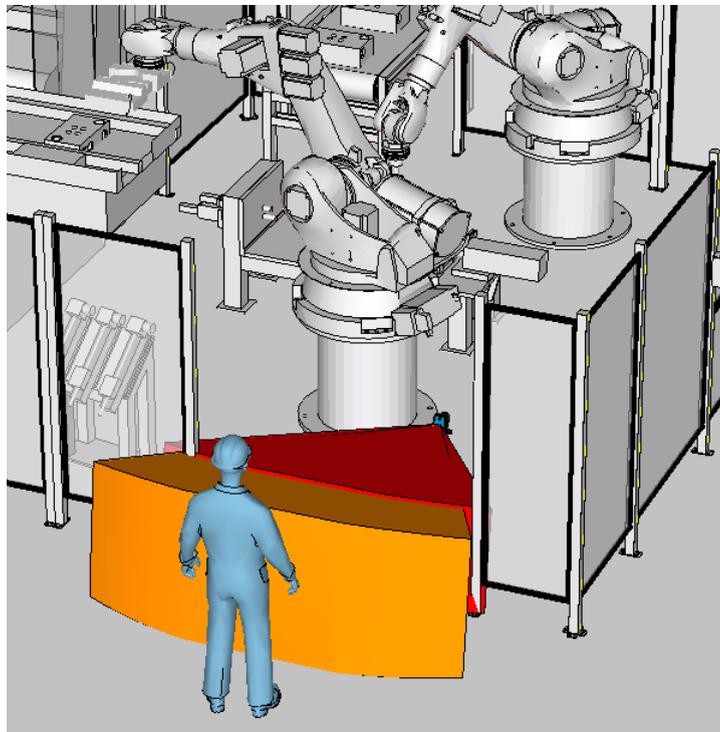
The first step in providing a solution is to define the number of sensors that are needed to fulfill the requirements and cover properly the area.

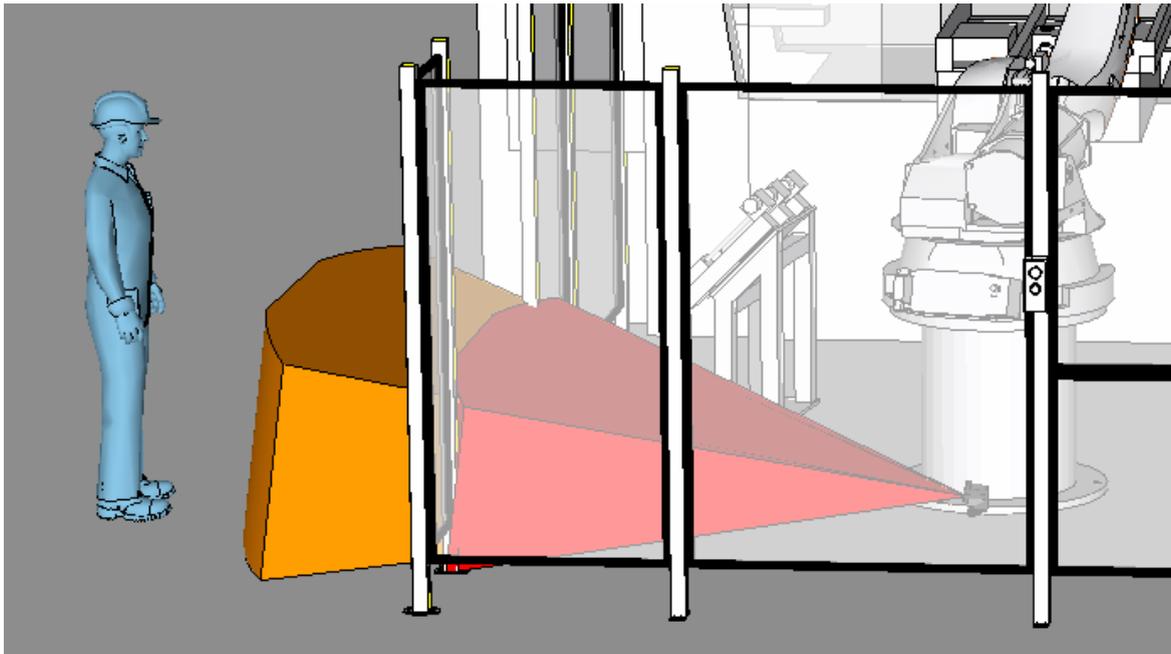
The number of sensors and above all the position of each one is very important to have a good result. For this reason is always suggested to get as many info as possible, like:

- a 2D layout with dimensions (DWG file)
- if possible, a 3D STEP file to see the shapes and the size of the static objects inside the cell
- pictures and videos are very welcome
- description of the working process

2.1 Access Detection

To protect Gate 2, it is possible to use one sensor with two safety zones. The orange zone will slow down the robots, while the red zone will completely stop them.





For the Access Detection safety function, consider always that the safety distance provided by the formula **$S=K \cdot T+850 \text{ mm}$** must be observed, where K is 1.6 m/s and T is the total system stopping time (Inxpect SRE 200 Series + machinery).

Note: the guaranteed response time for Inxpect SRE 200 Series is 100 ms.

2.2 Restart Prevention

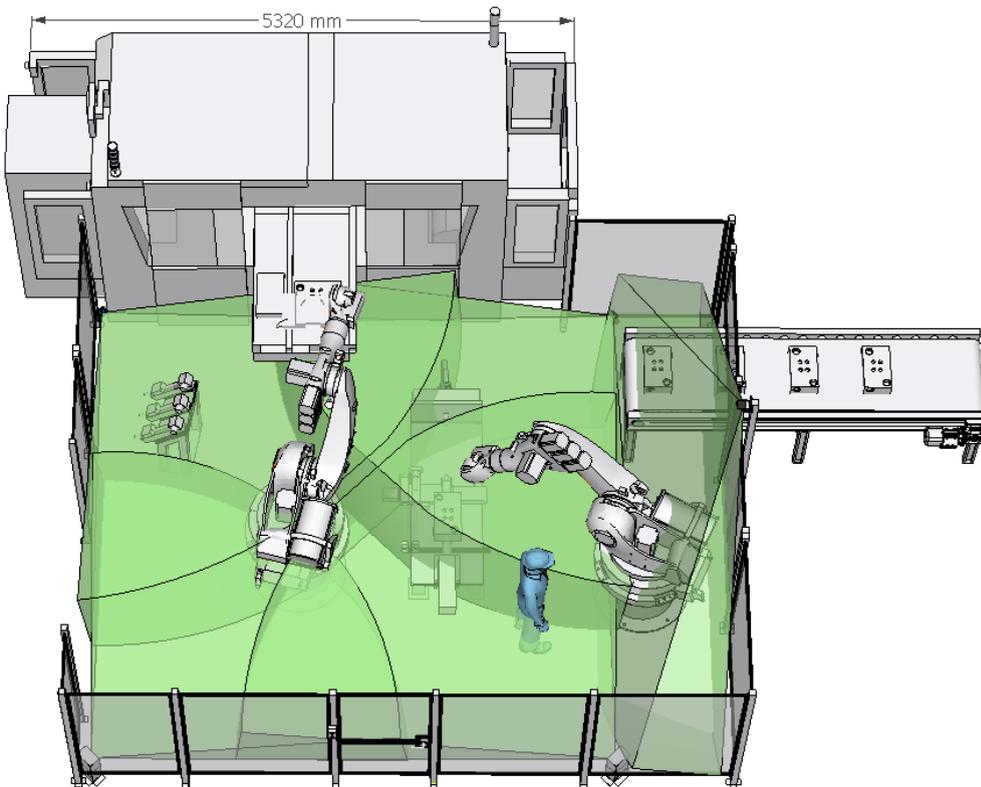
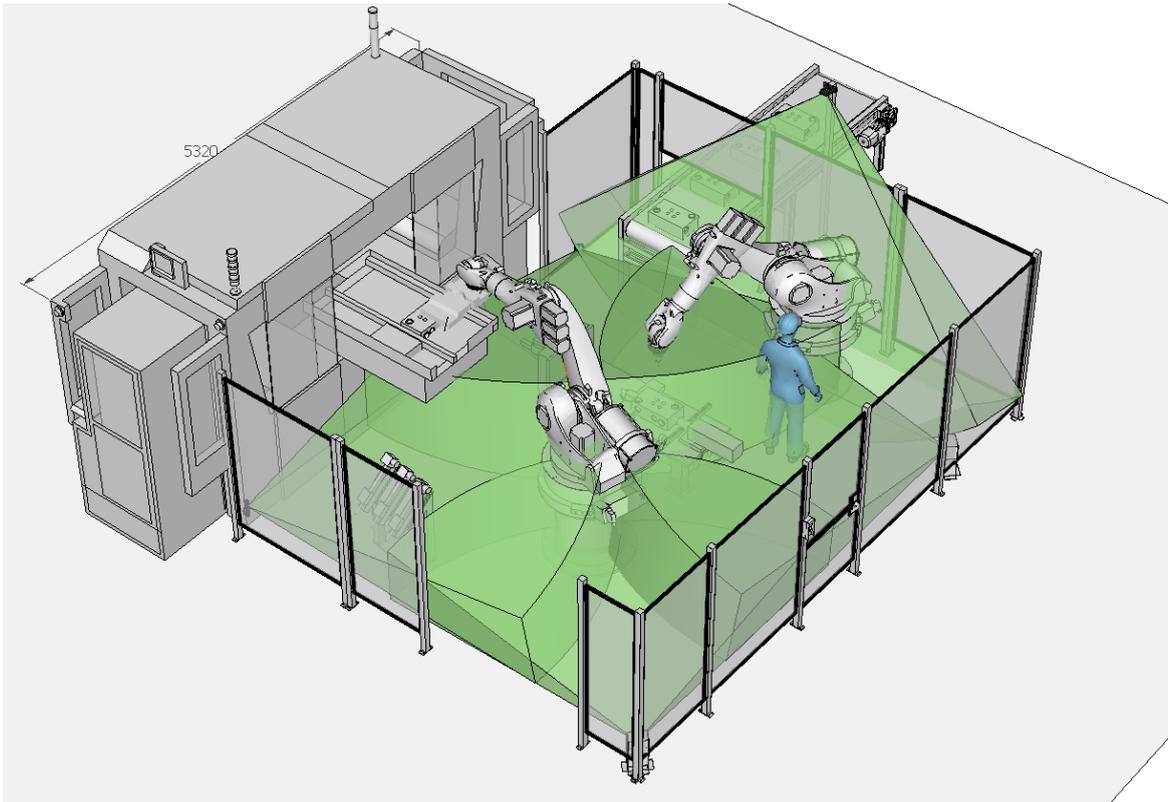
For covering the whole area in the inner part of the cell, 5 sensors are needed.

In this case, there are no formulas to facilitate either the number of sensors needed or their positioning. The target is to carefully cover the whole area, without leaving any blind spots where the operator could stay without being detected. Raised positions (i.e. on top of a conveyor) must be covered by the sensors whenever they are considered by the risk assessment.

Furthermore, best practice is to prevent possible reflections of the radar signal which could lead to monitoring unwanted areas outside of the cell. This is the case when the detection field of a radar is set to a long distance and nearby the sensor (in front of it or even at a generic angle within the configured angular coverage of the detection field) is present a static object.

The reflection can be risky every time that the detection field is configured with a distance 2 times greater than the distance to the reflecting object. Indeed, the reflection itself could scatter the signal behind the sensor outside the area that you would like to protect (for instance outside of the fences).

In the images below an example of correct positioning for 5 sensor acting as Restart Prevention



In the picture below you can find an example of a sensor placed in a risky position, due to reflections against the robot and with the detection field configured too long.



3. Software settings

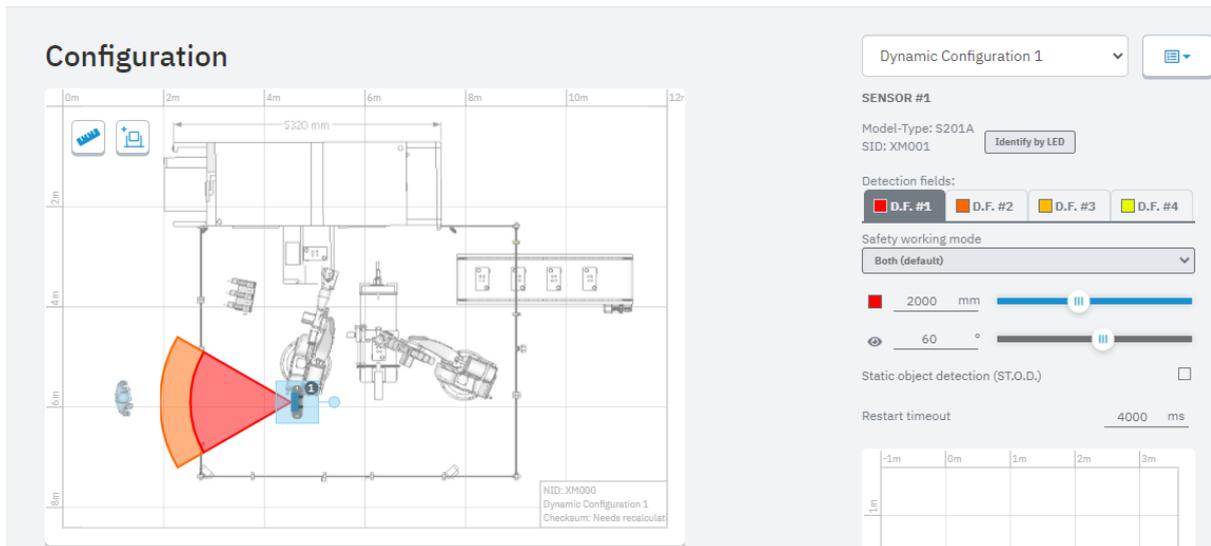
In order to configure the system, the Inxpect Safety software is needed. Its version must be compliant with the firmware on the control unit. Please check the file “*System Release Changelog*” downloadable from the Inxpect website under *Support > Inxpect Tools*.

As an alternative, download the latest version of the Inxpect Safety application from the Inxpect Tools web page. The latest version is always compliant even with an older firmware on the control unit.

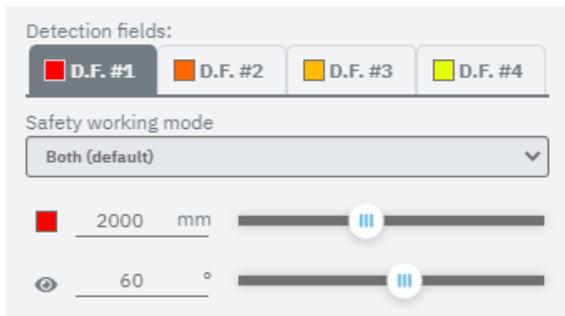
3.1 Layout and safety working modes

Best practice is to import a 2D layout on the “Configuration” page in order to visualize the position of the sensors and then validate the correct working of the system. The imported layout should be resized in the correct scale using the proper commands on the software.

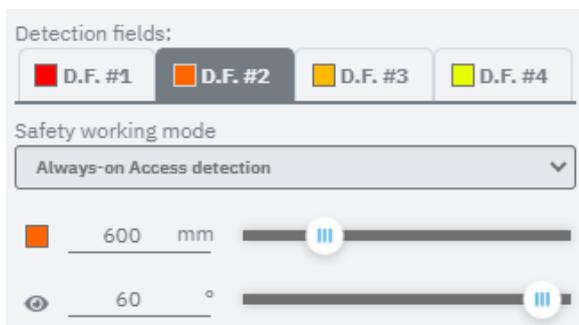
The image below shows the top view of the cell and sensor number 1 positioned and configured with 2 detection fields (red = D.F. #1, orange= D.F. #2)



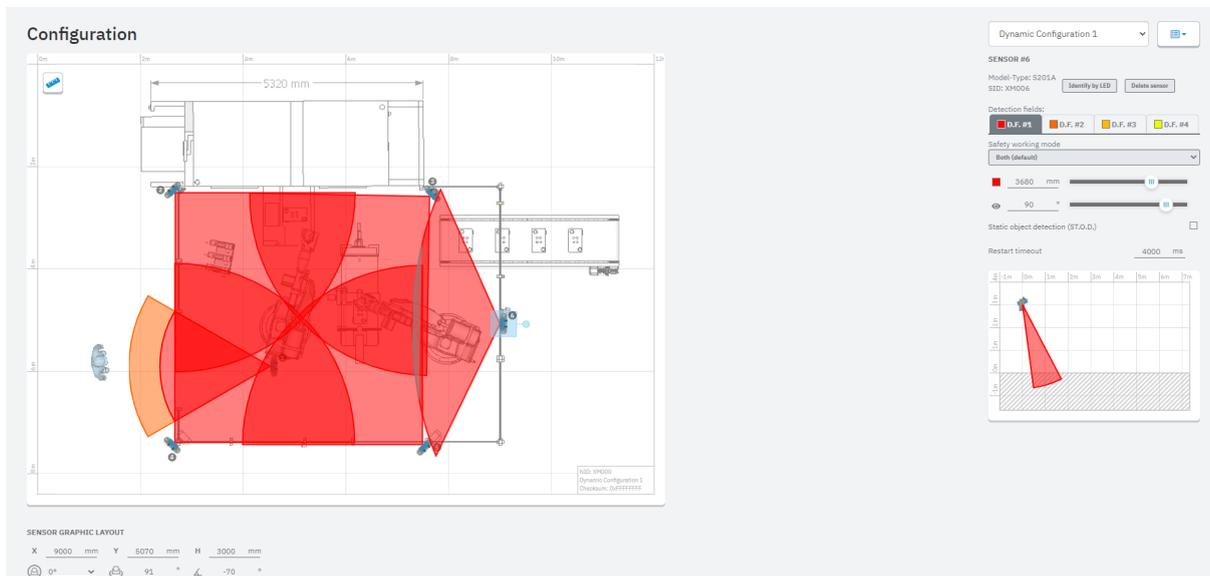
The detection field #1 has been configured with Safety working mode equal to “Both”. It means that when the operator will enter inside the red field the sensitivity of that area will switch to High sensitivity and the sensor will be able to detect even micro-movements (standing still person will be continuously detected)



The detection field #2 has been configured with Safety working mode equal to “Always-on Access detection”. It means that the sensitivity is set to detect a walking person. This area will never switch to high sensitivity. (optionally it can be configured as “Both” like the D.F. #1 if a standing person should keep the robot slowed down)



In order to add the other sensors for the Restart prevention, please click with the mouse on the specific button  , then place the sensors on the correct positions defined during the feasibility study and then set the detection field distances.



All the sensors between 2 and 6 have been configured with only one detection field, and safety working mode equal to “Both”.

In order to guarantee the Restart Prevention, it is mandatory to be able to detect even standing still operators. For this reason, the safety working mode must be set mandatory to “Both” or “Always Restart prevention”.

“Both” is the preferred choice, because it makes no sense to always keep the maximum sensitivity if a field is not firstly engaged.

NOTE: radar number 6 is positioned at 3 meters high. The visualization in 2D is not exhaustive and it seems that a portion of the area on the corners is not covered. By means of an external 3D modeling it is possible to verify that the whole area is covered.

During the “Validation” of the coverage it is also important to verify that every operator position is always detected.

3.2 Detection fields and associated outputs

In order to provide the correct signals to slow down and stop the robots it is necessary to associate the control unit safety outputs to the Detection Fields.

In this case two safety outputs (double channel) are needed because we are using two safety zones (red and orange).

The digital OSSD outputs can be configured in the page *Settings > Digital Input-Output* of the software.

When the orange field of sensor 1 will be engaged (i.e the operator enters in **Detection Field #2**) the robot must slow down. So it is needed to assign two OSSDs to be activated/deactivated in relationship with Detection Field #2. The name of this assignment is **Detection Signal #2**.

When an operator is inside one of the Detection Fields #1 (red zones) the robots must stop. So it is needed to assign two OSSDs to be activated/deactivated in relationship with **Detection Field #1**. The name of this assignment is **Detection Signal #1**.

NOTE: Detection Signal “X” is associated with Detection Field “X” of all the sensors, not with just a specific sensor. In order to receive precise information of which sensor is on alarm, it is necessary to use a communication over Fieldbus (e.g. PROFIsafe).

See the picture below to see the assignment for each OSSD.

The screenshot shows the 'Settings' menu on the left with 'Digital Input-Output' highlighted. The main area displays the 'Digital Outputs' configuration page. It contains a heading 'Digital Outputs' and a sub-heading 'Set the functionality of the control unit outputs.' Below this, there are four rows, each representing a digital output:

- Digital Output #1**: Detection signal 1
- Digital Output #2**: Detection signal 1
- Digital Output #3**: Detection signal 2
- Digital Output #4**: Detection signal 2

3.3 Muting and inputs

In this example, sensor #1 must be always active in order to detect the operator access.

Whereas the sensors between #2 and #6 should be activated only when the operator enters into the cell. During the normal robot working, the sensors between #2 and #6 must be kept in “muting”, otherwise they would trip an alarm at every robot movement.

For this reason it is needed to properly configure the muting function. In particular, it should be assigned the same group of muting for sensors between #2 and #6, and a different group or “none” to sensor 1, which should be always active.

Configure this feature in the menu *Settings > Muting* as shown in the picture below.

The screenshot shows the 'Settings' menu on the left with 'Muting' highlighted. The main area displays the 'Sensor groups' configuration page. It contains a heading 'Sensor groups' and a sub-heading 'Select the group for each connected sensor. The groups are used to allow selective muting on a set of sensors. If you don't use muting function or you just have one muting signal, leave the configuration to the default value.' Below this is a table with the following structure:

	None	Group 1	Group 2	Both
Sensor 1	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sensor 2	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Sensor 3	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Sensor 4	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Sensor 5	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Sensor 6	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

Furthermore it is necessary to configure a specific digital input to activate/deactivate the muting at the correct point in time. The group of sensor to be muted is group #2.

In the picture below, it is shown how to set the Digital Input #1 in order to activate/deactivate the muting on the group of sensor #2.

Settings

- General
- Node ID Assignment
- Digital Input-Output**
- Muting
- Restart function
- Anti-Tampering
- Network parameters

Digital Inputs

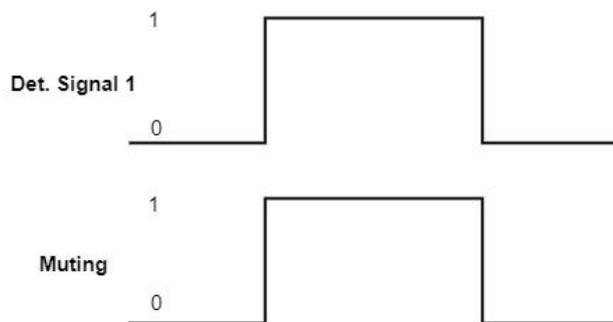
Set the functionality of the control unit inputs.

Digital Input #1

Digital Input #2

NOTE: the digital input#1 is a safe input (double channel).

NOTE 2: the muting is activated when both channels of the input are at 24 Vdc. The muting is deactivated when at least one of the channels is kept at 0 Vdc. This trend is according with the behavior of Detection signal #1; this means that Detection Signal #1 can be used to properly set the muting.



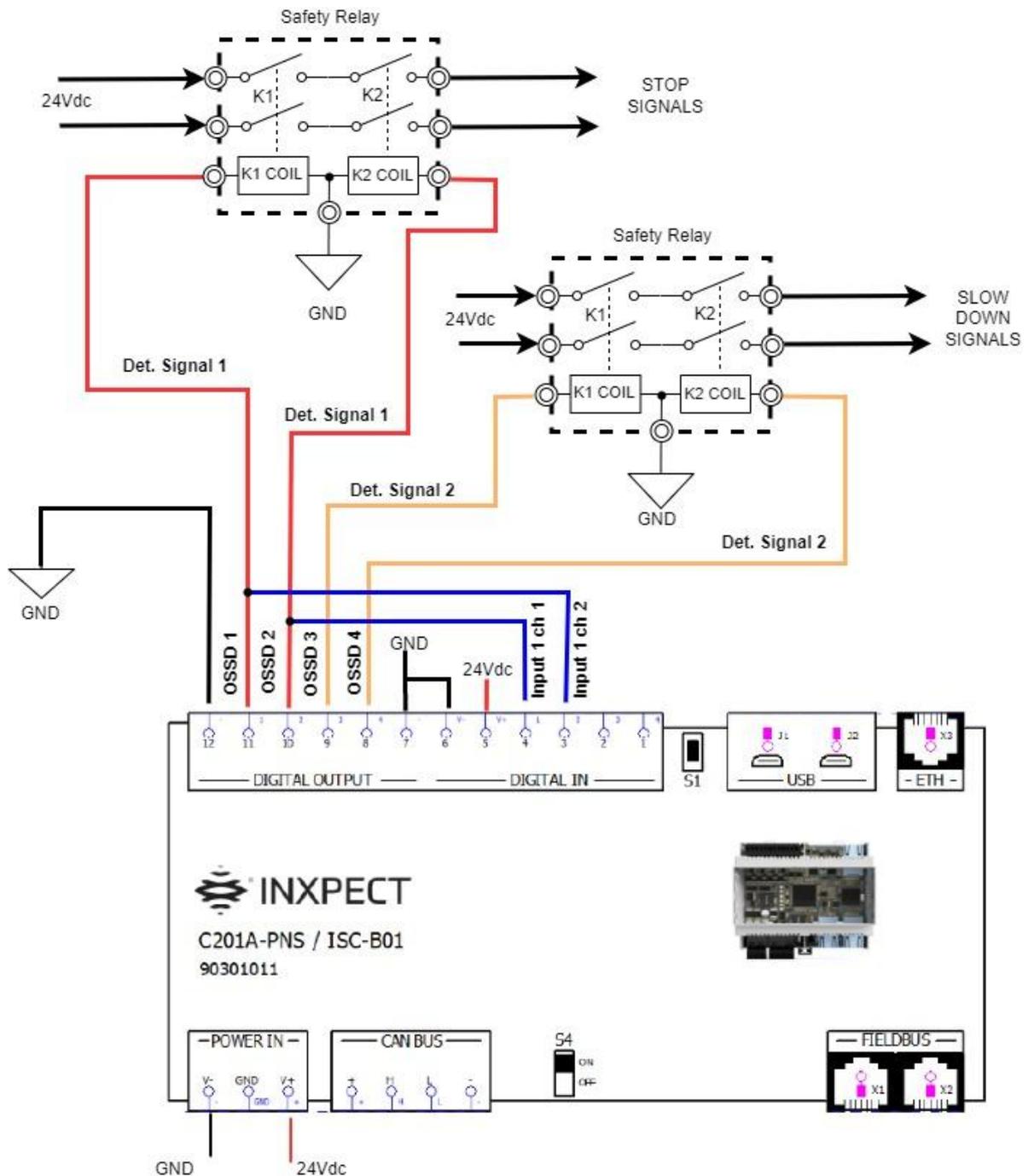
Detection Signal #1 = 0 ==> Operator inside Cell ==> Muting disabled

Detection Signal #1 = 1 ==> Area Free ==> Muting enabled

4. Electrical connections

In the following picture it is possible to see how to cable the control unit with two external safety relays that provide the stop and the slow down signals.

It is also shown how it is possible to tie the Detection Signal #1 (OSSD #1 & #2) to the Muting signal (Input #1 ch1 & ch2)



5. Optional - PROFIsafe communication

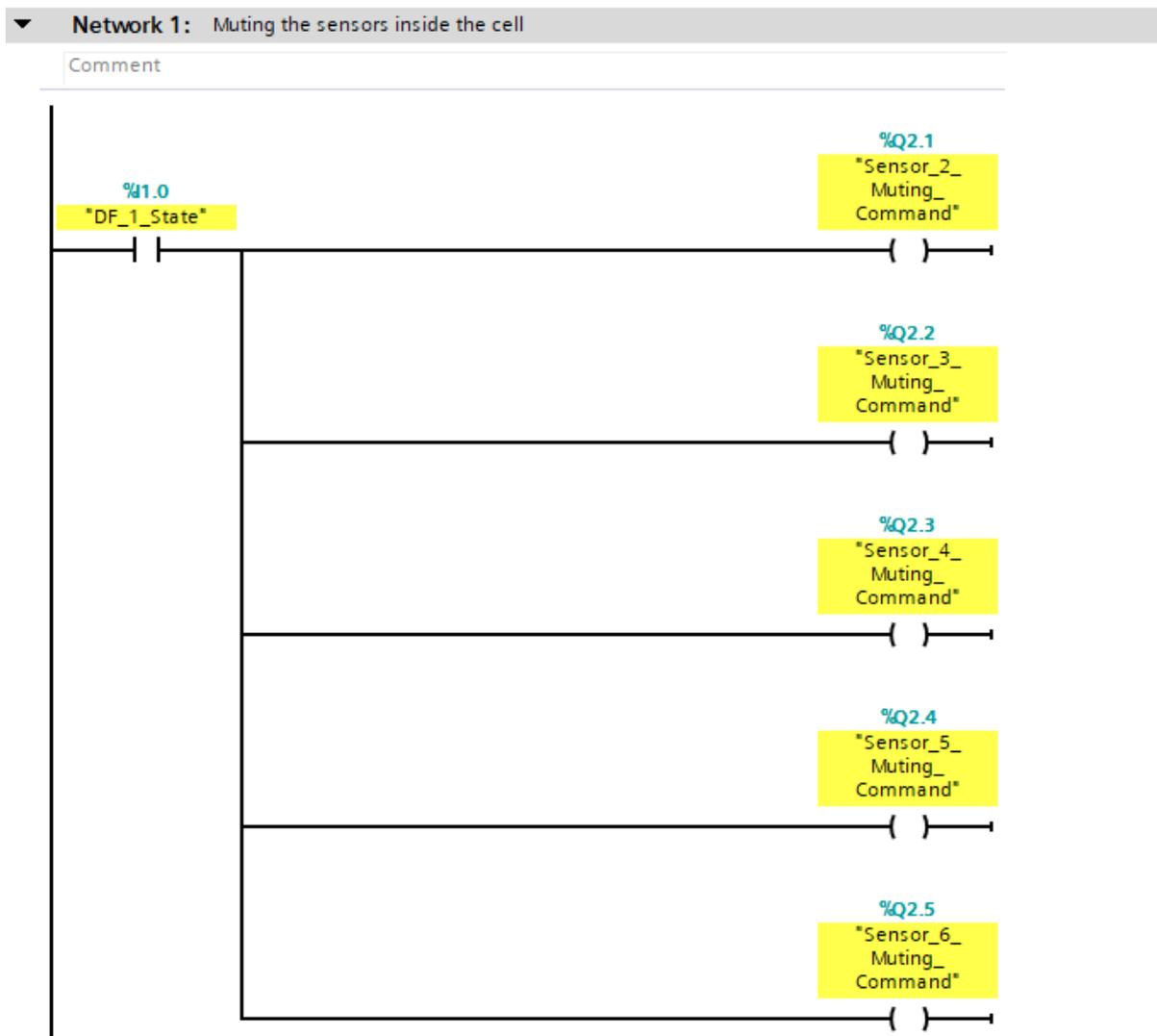
In case the Safety PLC is provided with the Profisafe protocol, the Digital Inputs & Outputs are no longer needed. In this case, just remove all the configured inputs and outputs and use the PROFIsafe protocol to communicate with the PLC.

NOTE: **physical inputs configuration has the higher priority compared to Fieldbus.** Remember to delete their configuration if you don't need to use them.

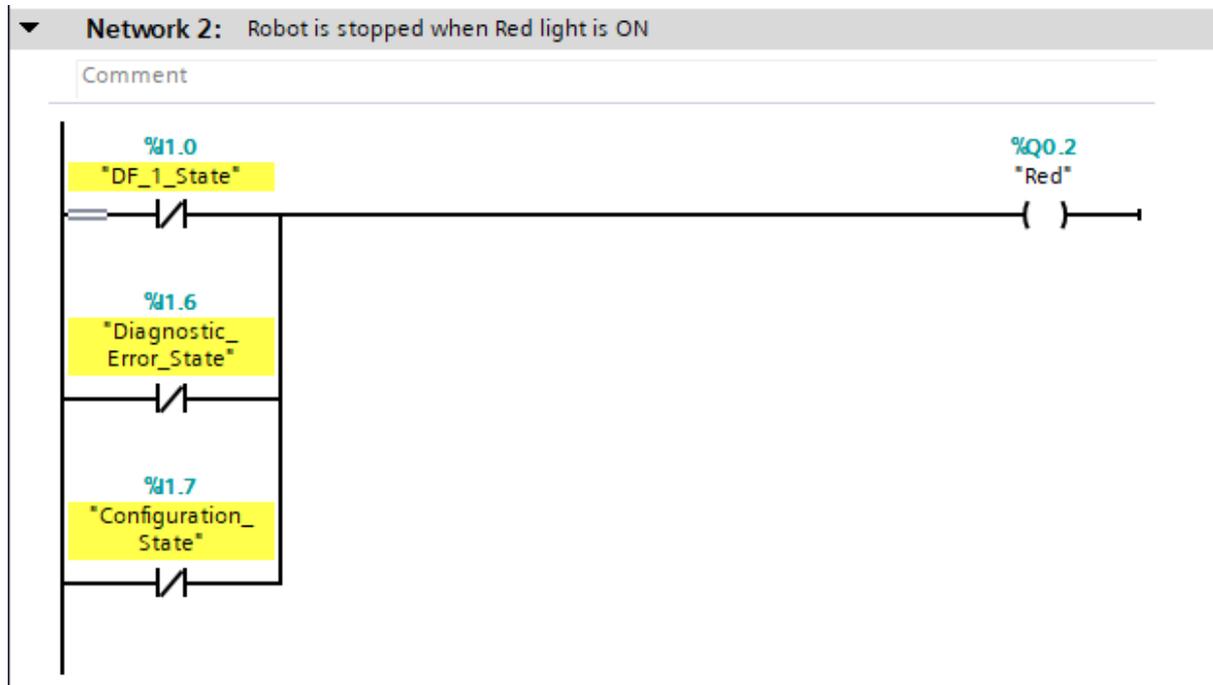
For PROFIsafe protocol explanation refer to the document "PROFIsafe Reference Guide" available on the Inxpect Tools web page.

In this example we will use the safe data contained in the first Safe Module, named "Configuration and Status Module".

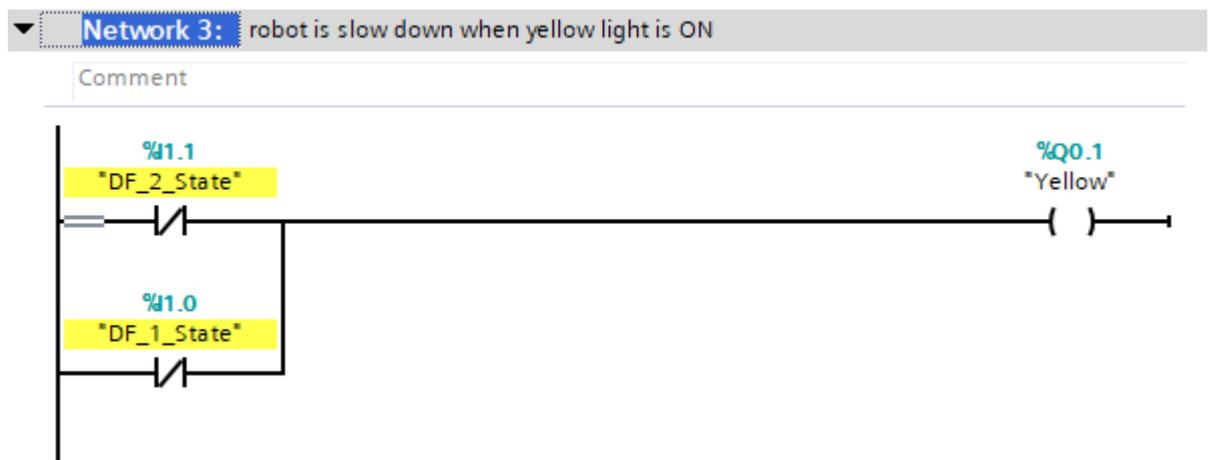
Below you can find an example of how to set the Muting on the sensors between #2 and #6. The Muting is directly tied to the behavior of Detection Field #1. When DF#1 is high, it means that the inner area of the cell is clear and the muting can be activated on the sensors inside the cell.



In Network 2, you can find an example on how to stop the robot. Whenever the DF#1 is engaged (low level), the RED light must switch ON and stop the robot. In the same way, the robot should stop if a diagnostic error occurs on the safety system.



In Network 3, you can find an example on how to slow down the robot. The signal for slow down (yellow light) should be provided whenever the DF#2 is engaged or the DF#1 is engaged. In the latter situation the robot is also stopped due to “Network 2”



In Network 4, you can find an example of how to automatically restart the robot. All the conditions in line must be at high level to enable the restart of the robot.

