Robot: implementation guide for a safe PES APPLIED ROBOTICS Automatic Tool Changer in a Profinet or Interbus architecture.

Important note : This document has been translated from the French. In the event of any dispute, only the French version is referred to as the reference text and is binding on the parties

Scope:

This document describes the operating principle of a safe PES APPLIED ROBOTICS Automatic Tool Changer (COA).
It defines the implementation rules of the electric interfaces, the implementation safety measures and software functions to be used.

Context:

Field of application
- Robot with bay at the Renault standard.
  ABB Robot with IRC5 type bay
  Robot KUKA with KRC4 type bay

Transmitter: Plant 65940 Engineering Automatisms and Robotics

Availability:

In-house Renault, on Intranet: http://gdxpegi.ava.tcr.renault.fr
In external Renault, on Internet: www.cnomo.com
E-mail: norminfo.moyens@renault.com

History:

Version	Update	Main modification	Referent
A	11/2012	First Issue Cancels and replaces the documents : **GE03.MO.136 et GE03.MO.165**	bodywork automation upstream and exhaust UET

Approved by	*Designation*	*Signature*	*Date of application*
JOUAIRE Alain	Department head 65940		11/2012

Content

1 Foreword

This document describes the operating principles and integration rules of **a** safe PES **A**utomatic **T**ool Changer **(COA)** installed on a automated robot or gantry crane facility (called carrier in this document).

It defines the implementation rules of electric interfaces, the treatments of the safety measures and the software functions to be used.

This document relates only to the robots equipped with the RENAULT standard application.

Note 1: In this document, the expression “manual command or controlling” corresponds to the movement requests made by a service personnel from a console (bay or API) through dedicated buttons for controlling (control/command) safely (mode selector on manual, etc.)

Note 2: The Interbus and Profinet interfaces of the tool changers are different and it will be necessary to ensure the command of the hardware of the field bus type used.

2 General principles

Irrespective of the tool type “to be changed” (gun, gripper, etc.) the management of the COA is ensured by the API of the installation and the manual commands of the console of the carrier by using a sequence of the handling “gripper” function.

It is impossible to manage this kind of changer made safe with a robot which itself controls the gripper (type: e.g.5 sequences).

Consequently, for the implementation of a COA, refer also to the document **GE03.C0.020** “Implementation guide for grippers controlled by API in Profinet” or **GE03.C0.021** “Implementation guide for grippers controlled by API in Interbus”.

The COA is a mechanical device composed of a part fixed on the last axis of the carrier (called carrier side 1/2 changer) and a second part fixed on the tool (called tool side 1/2 changer). These two parts can be coupled/disconnected according to the requirement of the process. This device makes it possible to:

- Change a tool to satisfy production diversity (e.g.: placing a tool A and catching a tool B, etc.)
- Place the tool with the part in the machine (e.g.: place gripper + part, pointing with a welding gun, taking again an empty gripper)
- Place the tool in a location dedicated for an obstruction problem when two tools are loaded on the carrier (e.g.: welding robot + gripper with placing of gripping before going to weld).

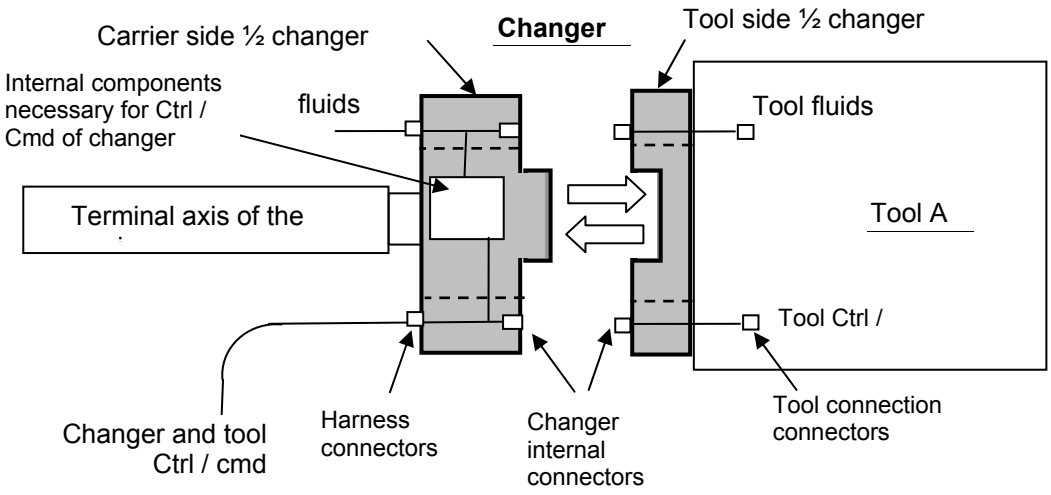
The two parts of the COA are disconnected/coupled via an unlocking/locking function. When these two parts are coupled and locked the COA ensures the continuity of energies necessary to control/command of the tool as well as for CEM aspects, the electrical continuity of the metallic grounds of the ½ changers.

The carrier side is equipped with:

- - locations making it possible to have the electrical/pneumatic/hydraulic “connectors” necessary to the operation of the tool and the changer.

The tool side is equipped with:

- - locations, with regard to those placed on the carrier part, allowing to have the electric/pneumatic/hydraulic “connectors” necessary to the operation of the tool.



2.1 Control/command Management of COA

Unlocking is carried out via an electric command. The components (sensors/actuators) necessary for control/command management are integrated in the “carrier side” part:

- An electric command of unlocking,
- An electric control of unlocking,
- An electric control of locking,
- An electric control of presence of the tool or changer ready to be locked. This information indicates that the two parts “carrier side and tool side” are properly in contact and that the changer can be locked (safety sensor),
- Unlocking Air pressure control,
- Locking Air pressure control,
- A safe air pressure control (the secured air makes it possible the landing during failures of the interns pneumatic circuit in the COA),
- A control of the tool except placing support. This information indicates that the tool is not present any more on the placing cabinet and that the unlocking is impossible (safety switch to trigger or fork).

2.2 Safety of the COA unlocking

The unlocking of the changer causes tool “release”. This action is dangerous for the service personnel.

From design part of PES changer, an unlocking command given outside the position of the robot “tool on transfer plate” will not have any effect except if all the tools are positioned on their transfer plate and that “tool presence” information (previously “ready to lock”) is not active (no tool carried by the robot, phase or the robot is in trajectory after placing or before catch).

Indeed, to carry out an unlocking with tool, the robot must be in a position dedicated to the placing of the tool. On this tool a safety switch is which is then engaged in a fork of the transfer plate (of type wastes of door). This safety switch makes it possible to supply a solenoid valve of the “secure air” distributor. There are two other distributors for locking and unlocking.

Safety principle by pneumatic circuit.

Note: this diagram and the principle described belongs to PES company

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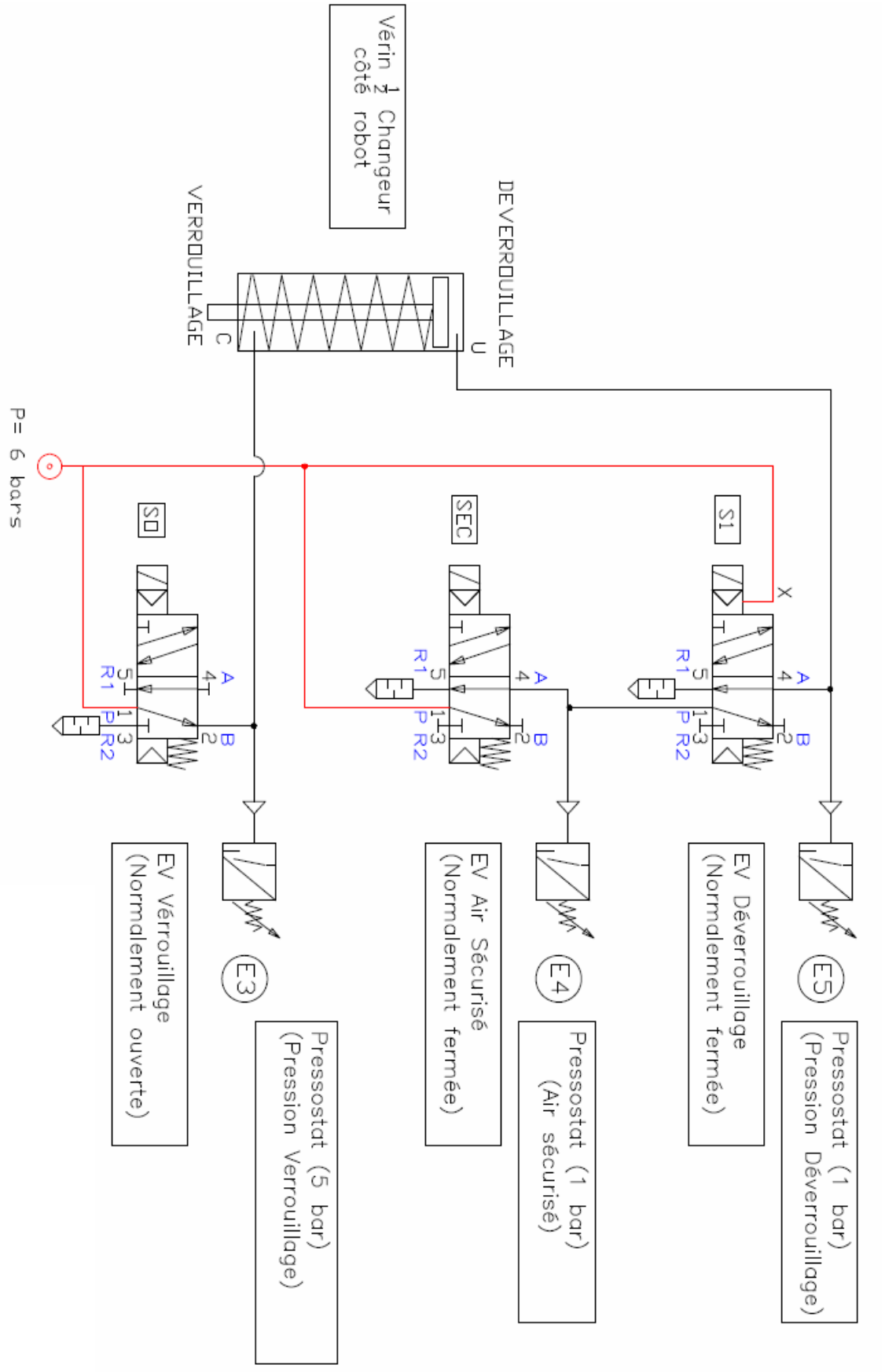
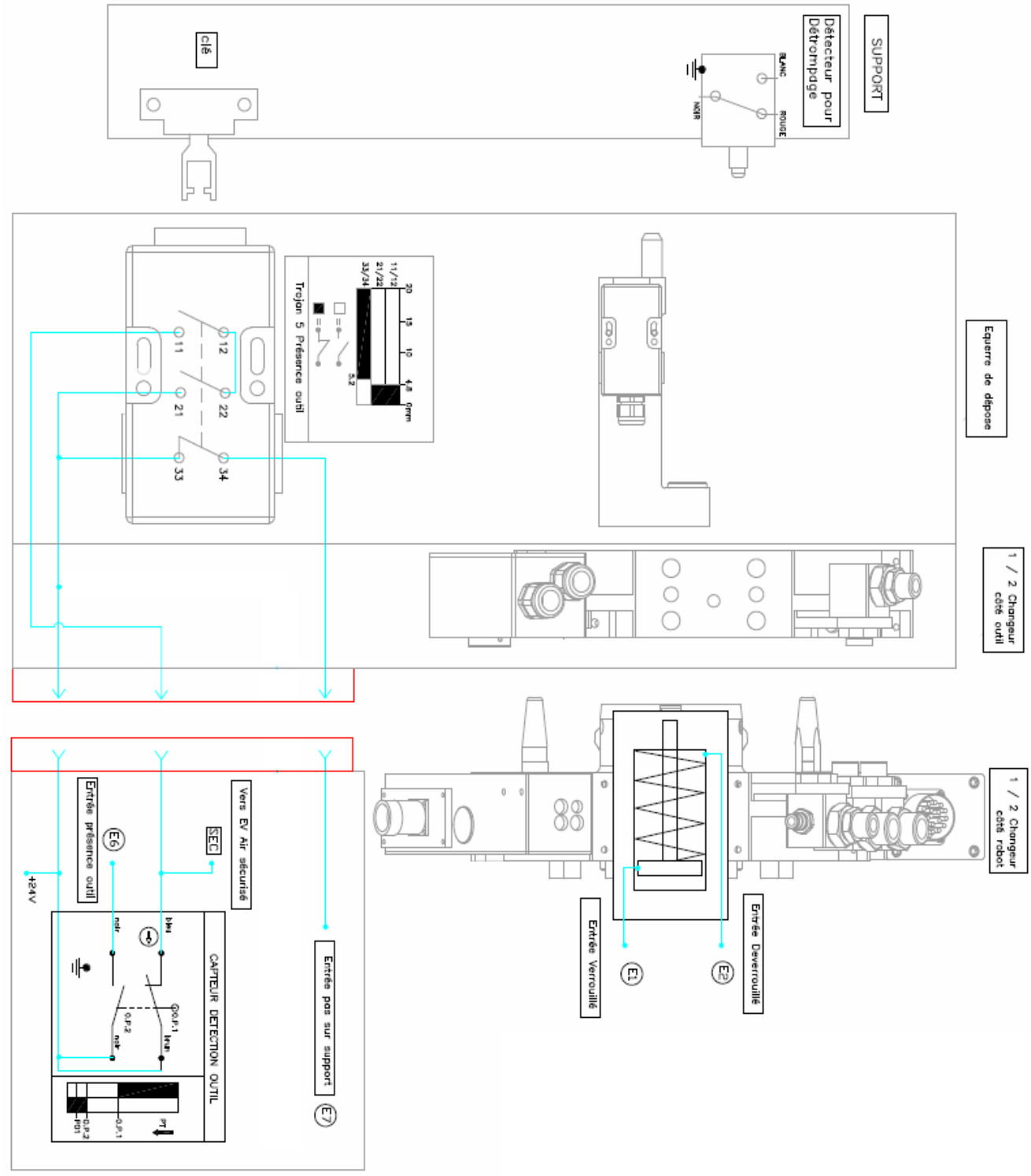


Safety principle by electrical circuit.

Note: this diagram and the principle described belong to PES company.

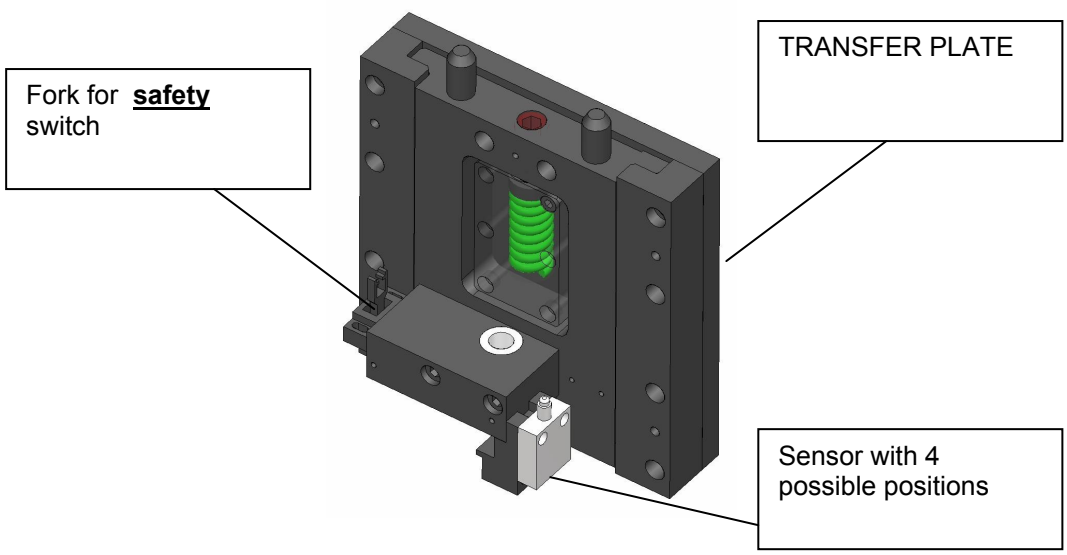


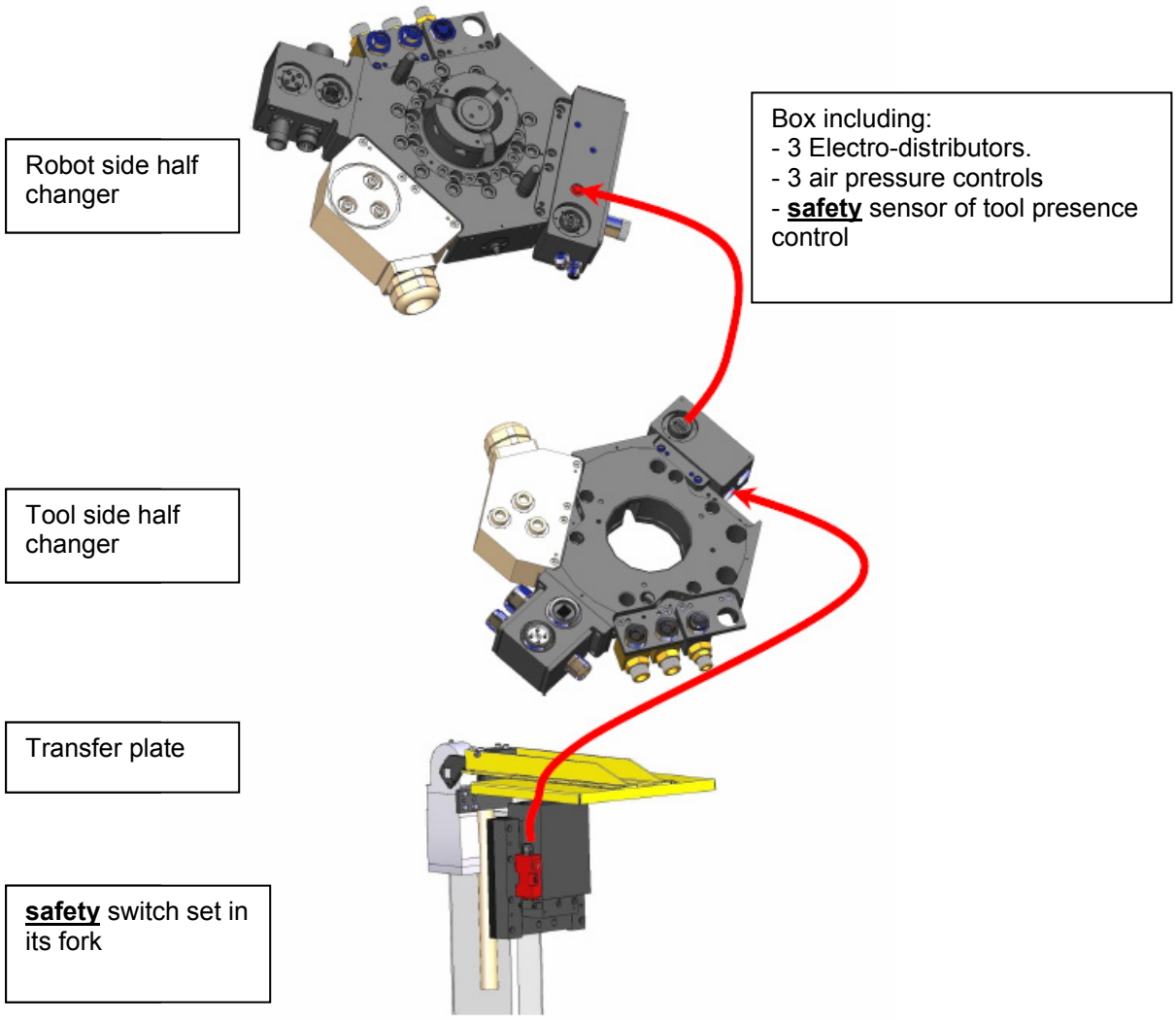
2.2.1Commands safety

The controlling in manual command of unlocking is possible only when the loaded tool is on its placing position.

From the “safe” design part of PES changer it is however possible:

- to carry out the locking/unlocking commands with maintenance door open
- to carry out the locking/unlocking commands except position on transfer plate if the robot does not load any tool and that the tools are in position on the transfer plates. This is made possible thanks to the use of a tools presence safety sensor.


Fork for **safety** switch
TRANSFER PLATE
Sensor with 4 possible positions


Robot side half changer
Box including:
- 3 Electro-distributors.
- 3 air pressure controls
- **safety** sensor of tool presence control
Tool side half changer
Transfer plate
safety switch set in its fork

2.2.2 Process safety

The tools which are not at the end of the carrier are placed in dedicated “placing locations” called as follows further in the document:

- “Transfer plates”: they represent the placing locations where the tools are not operational for the process in progress (tool on standby).
- “Assemblies”: they represent the placing locations where the tools are operational for the process in progress (placing in the machine: e.g. positioning - assembling).

In order to make the unlocking function safe, each placing location controls the presence of a tool via a dedicated mechanical detector. If need be an inductive detector could be set up in order to control as well as for good installation of the tool. For each placing location, a control of the proper operation and consistency of the sensor(s) is carried out by the API program.

Note: In the case of placing location in the assembly like positioning-assembling, it is necessary to set up a fork adapted to the safety switch and a detector associated with a remarkable position with dedicated placing.

Case 1: Tools are used with only one dedicated transfer plate for each tool (classical case):

- The controlling of unlocking automatically and manually is authorised only if all the tool placing locations are occupied. This indicates that all the tools not in use are in their dedicated location and that the carrier with its loaded tool is well positioned in its dedicated placing location.

Case 2: Tools can be placed in the dedicated transfer plate or the “assembly”:

The controlling of unlocking automatically and manually is authorised only if:

- The tool(s) on two locations are controlled in their presence and consistently in one of the two placing locations and that the tools on only one site are controlled in their presence and consistently in their placing location.

Case 3: Only one placing location used in process by the carrier (e.g.: revolving warehouse):

- The controlling of unlocking automatically and manually is authorised only if the tool placing location dedicated for this tool is controlled in their presence and consistently. This indicates that the carrier with its loaded tool is well placing locationed in its placing location.

In order to avoid the tool placing locationing errors in these placing locations (e.g.: place tool A in the location of tool B), it is desirable that the tool presence control devices in the placing locations are placed so that only the expected tool can be detected correctly in its placing dedicated location. If several tools can be placed in the same location in the “assembly”, it is preferable that each tool has its own detectors.

If for a maintenance action, a tool is temporarily unavailable in its dedicated placing location, its presence must be simulated in order to allow the unlocking of the COA for the other tools.

2.3 Recognition of the tool loaded on the carrier

Done through the tool presence controls in each placing location (Example for two tools: tool A is in its placing location and the changer is full (ready to be locked and locked control to 1): it is the tool B which is in the changer.

2.4 Protection of the tools in the transfer plates

- Tool in the transfer plate:

When a tool is in its transfer plate, it is necessary to protect its ½ changer though a protector: cap, shutter, etc. against the position risks (welding environment, dust, projections, etc.) or deterioration of the electrical contacts (clogging, short-circuit) and the mechanical supports.

This protector is managed by the API and must be controlled in flip-flop (progress/recoil) electrically controlled. If there are several transfer plates they can, according to their establishments, be commanded by one or more EV bistable.

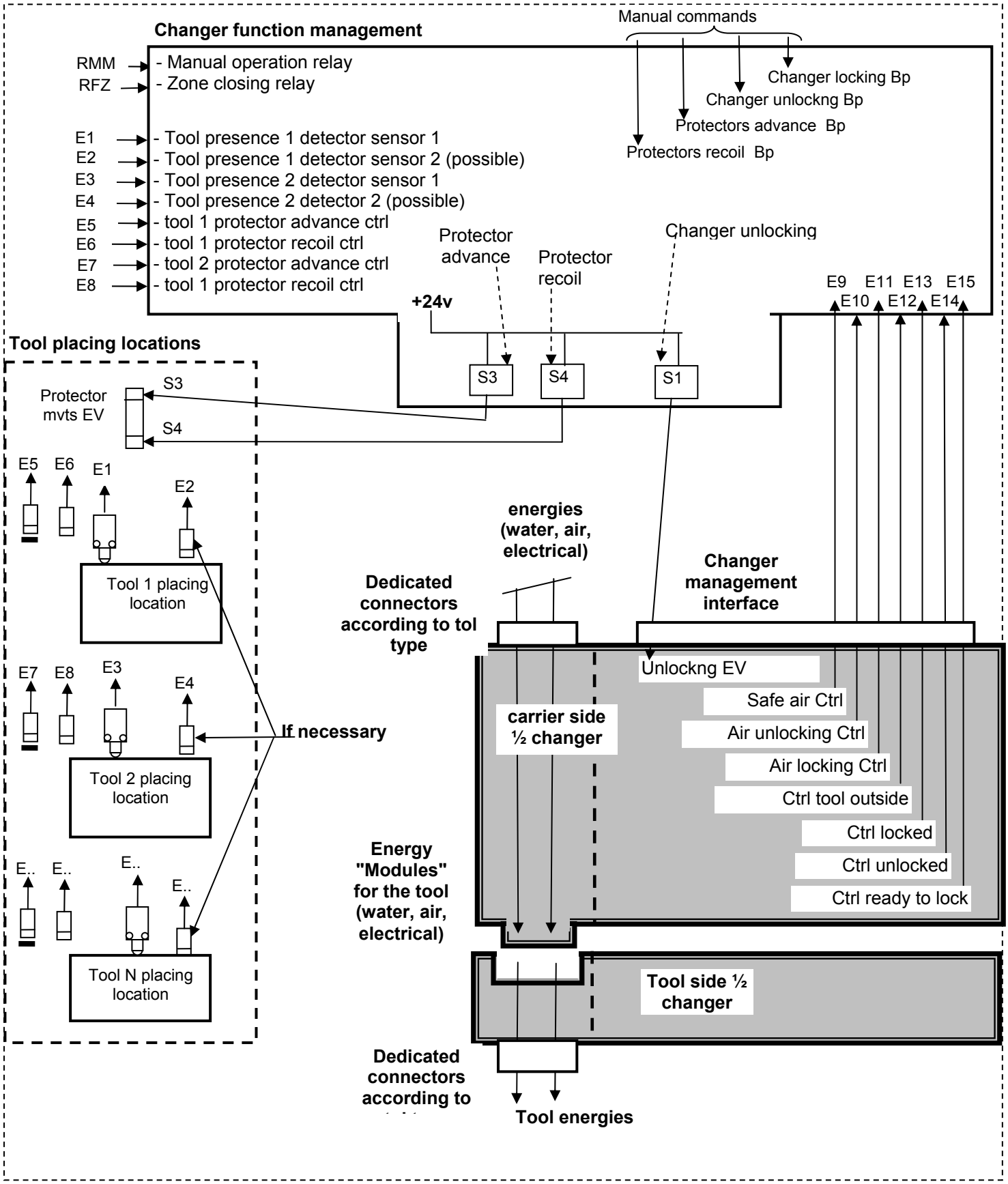
In the absence of tool in a transfer plate, it is desirable to close again the protector in order to avoid clogging during closing after the placing of the tool.

- Tool in the assembly:

A protector can be planned according to the requirements and the possibilities of installation.

To see within the framework of the installation.

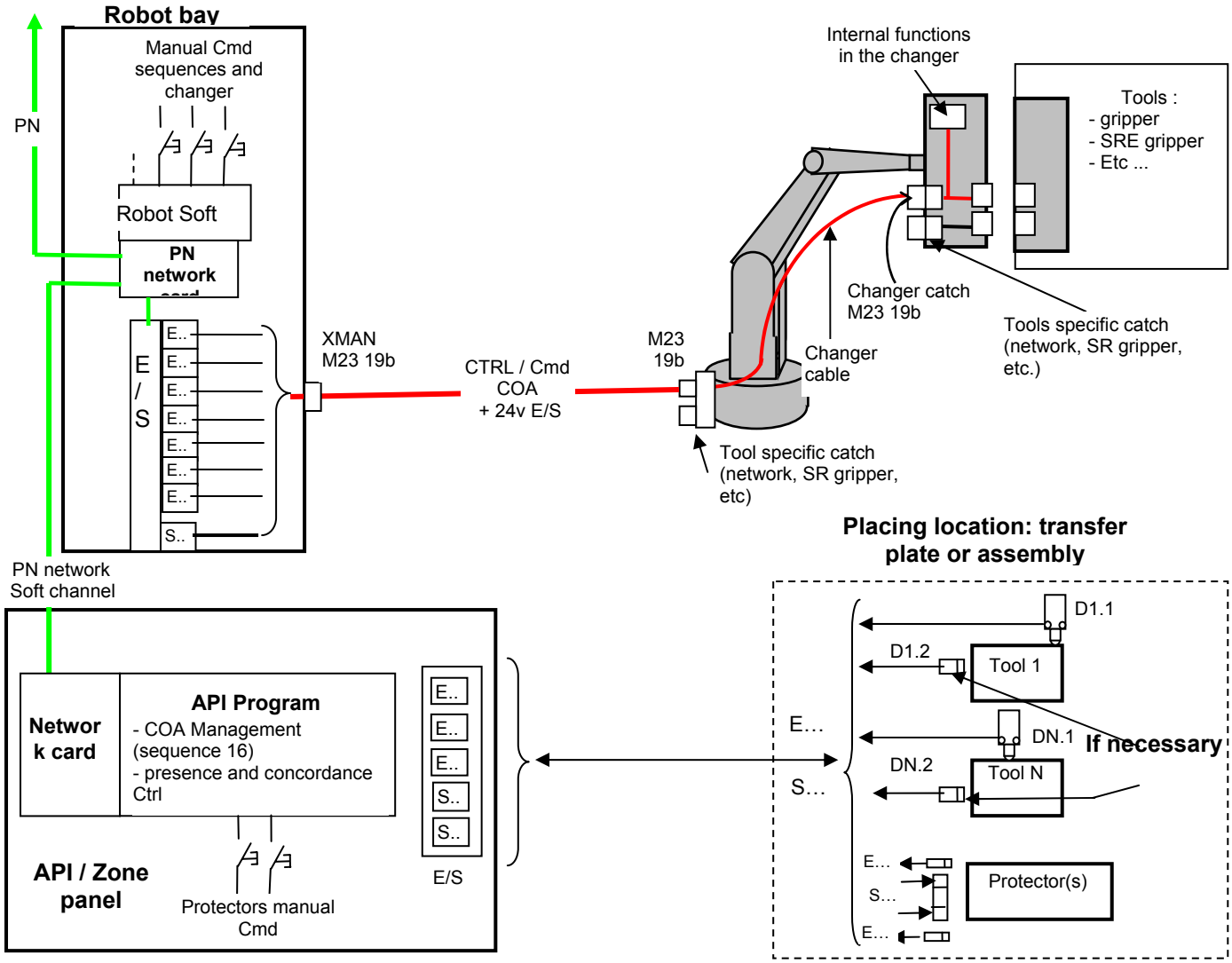
2.5 Functional diagram of COA



3 COA: specificities related to network PROFINET

This chapter explains the implementation of a COA PES made safe on robots with profinet network.
The robots are with the Scube Renault standard.

3.1 Synoptic of management COA with bay robot on Profinet network



3.2 Electrical interface

The control/command Management of the COA is ensured by the API through the inputs/outputs of the robot which are useful only in this “letter-box” application.
The electric interface of the carrier side COA is the M23 19 pins catch.

This interface contains the unlocking ctrl/cmd functions of the COA as well as 24V i/o necessary for the controlling of the tools assembled on the changer.

3.3 Robot harness

Gripper/gripper changer

The harness is composed of:

- The pneumatic connection,
- The M23 19 pins connection referenced above, between carrier and command bay
- The M12 “network” plug which ensures the management of the gripper sequences.

SRE gun/SRE gun changer

The harness is composed of:

- The pneumatic connection,
- Hydraulic connections,
- The M23 19 pins connection referenced above, between the carrier and command bay
- The motor “power” and specific brake plug according to the robot,
- The “coder” specific plug according to the robot,
- The “gripper information” plug in M23 19 pins,
- The “power welding” interface according to the type of robot.

SRE gun/Gripper changer

The harness is composed of:

- The pneumatic connection,
- Hydraulic connections,
- The M23 19 pins connection referenced above, between the carrier and command bay
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- The “coder” specific plug according to the robot,
- The “gripper information” plug in M23 19 pins,
- The “power welding” interface according to the type of robot.
- The M12 “network” plug which ensures the management of the gripper sequences.

3.4 Profinet network framework: information dedicated to the COA

Control information of the COA from the robot is written in the 3rd word of the framework.

➔ They must be used in API program, for the management of 16 sequences in order to generate the movement authorisations, advance and recoil information of the COA and the diagnosis.

	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
S1	Robot States/environment															
S2	API commands															
S3	DM 32	DM 16	DM8	DM4	DM2	DM1	CP air			**Tool outside support**	**Safe Air Ctrl.**	**Locking air control**	**Unlocking air control**	**Tool presence ctrl**	**Locking ctrl**	**Unlocking ctrl**

The COA command information result from API is resulting from the 4th word of the framework.

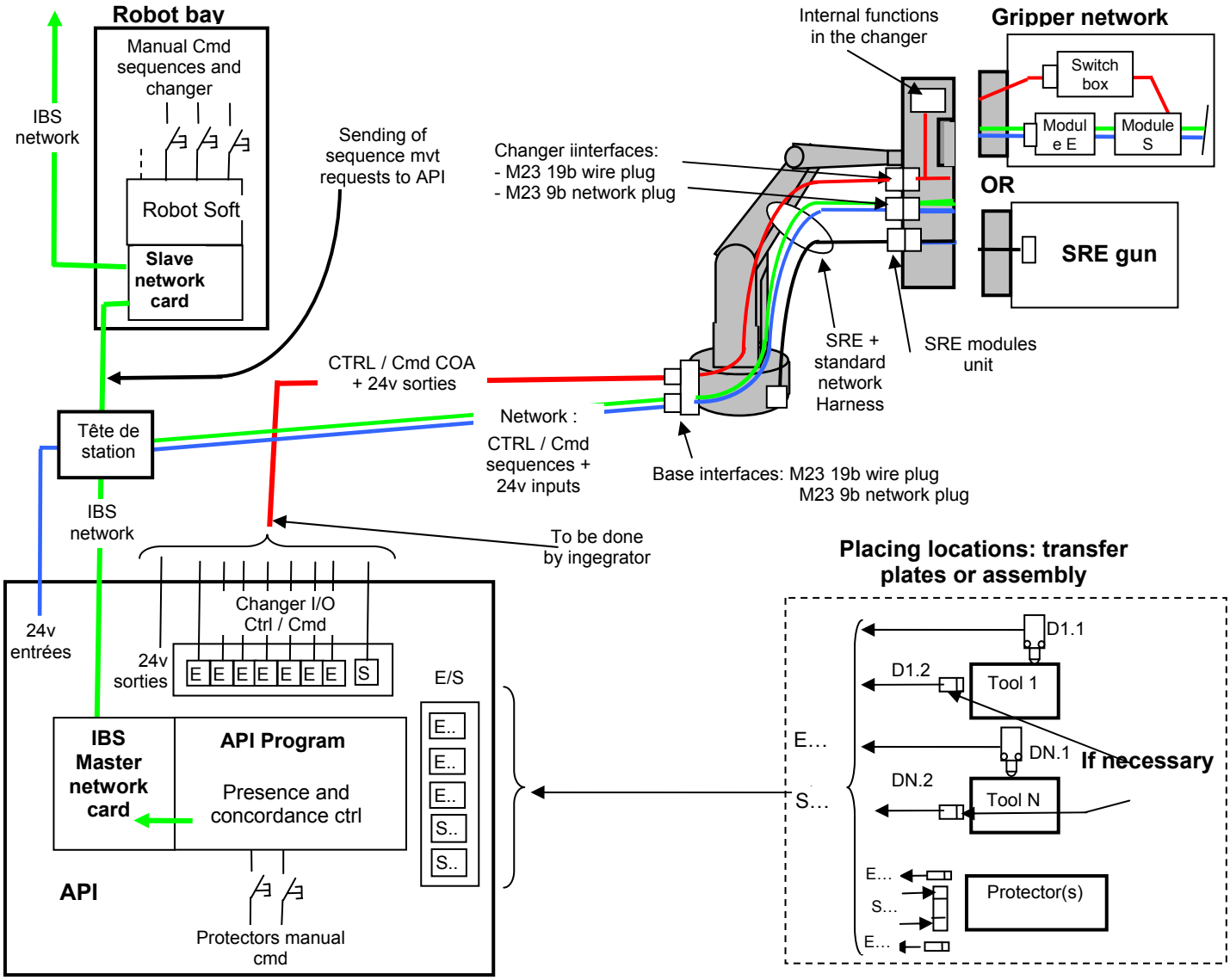
It represents the unlocking output of the MOUV2P1 of sequence 16.

	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
E1	Programs codes/environment exchanges															
E2	API events															
E3	Environment															
E4								**Unlocking Command**	ES 2 AV	ES 2 RE	ES 1 AV	ES 1 RE	GS 8	GS 4	GS 2	GS 1

4 Implementation COA: specificities related to network INTERBUS

This chapter explains the implementation of a COA PES made safe on robots with Interbus network.
The robots are with the Renault standard.

4.1 Block diagram of COA management with robot bay on Interbus network



4.2 Electrical interface

The controls/command management of the COA is directly ensured by the API.
The electrical interface of the carrier side COA is the M23 19 pins plug connected directly to the API.

This interface contains the COA unlocking ctrl/cmd functions as well as 24V i/o necessary for the controlling of the tools assembled on the changer.

4.3 Robot harness

Gripper/gripper changer

The harness is composed of:

- The pneumatic connection,
- The M23 19 pins “wire” plug which contains the COA management functions as well as the 24V of actuators command of the sequences connected directly to the API.
- The M23 9 pins “network” plug which contains the sequences management of the gripper as well as the 24V necessary for the supply of i/o modules and the control inputs of the sequences.

SRE gun/SRE gun changer

The harness is composed of:

- The pneumatic connection,
- Hydraulic connections,
- The M23 19 pins “wire” plug which contains the COA management functions as well as the 24V of actuator command of the sequences connected directly to the API.
- The motor “power” plug and specific brake according to the robot,
- The “coder” specific plug according to the robot,
- The M23 19 pin “gripper information” plug,
- The “welding power” interface according to the type of robot.

SRE gun/gripper changer

The harness is composed of:

- The pneumatic connection,
- Hydraulic connections,
- The M23 19 pins “wire” plug which contains the COA management functions as well as the 24V of actuators command of the sequences connected directly to the API.
- The motor “power” plug and specific brake according to the robot,
- The “coder” specific plug according to the robot,
- The M23 19 pin “gripper information” plug,
- The “welding power” interface according to the type of robot
- The M23 9 pins “network” plug which contains the sequences management of the gripper as well as the 24V necessary for the supply of i/o modules and the control inputs of the sequences.

5 Assignment of information of the M23 catch 19 pins

It is important that the output controlling the EV of unlocking command is assigned on a card with a common **permanent 24V**. This latching output is maintained even when there is an emergency shutdown until the locking request by the robot.

1	Locking air Control (E)		
2	Locked Control (E)	11	…
3	…	12	Ground
4	Safety air control (E)	13	Unlocked Control (E)
5	Unlocking air control (E)	14	Tool outside support (E)
6	0V of outputs	15	…
7	…	16	0V Electronic/Input
8	**Unlocking Command** (**S**)	17	24V Electronic/Input
9	tool presence control (E)	18	…
10	…	19	24v Outputs

6 COA Controlling

6.1 Robot side

It is the API which carries out the control/command functions of the sequences and the COA.

For the robots whose gripper is controlled by the API through a profinet network, the manual locking/unlocking command of the COA through the 16 sequences, is already carried out (dedicated press buttons in the screen of the sequences of the robot console).

This screen also makes it possible to permanently view the locking/unlocking state.

➔ See **GE03.C0.020**: Implementation guide for robot grippers controlled by API in Profinet

For the robots whose gripper is controlled by the API through an interbus network, the manual locking/unlocking command of the COA will be assigned to sequence 16 (dedicated press buttons in the screen of the sequences of the robot console).

➔ See **GE03.C0.021**: Implementation guide for robot grippers controlled by API in Interbus

6.2 API side

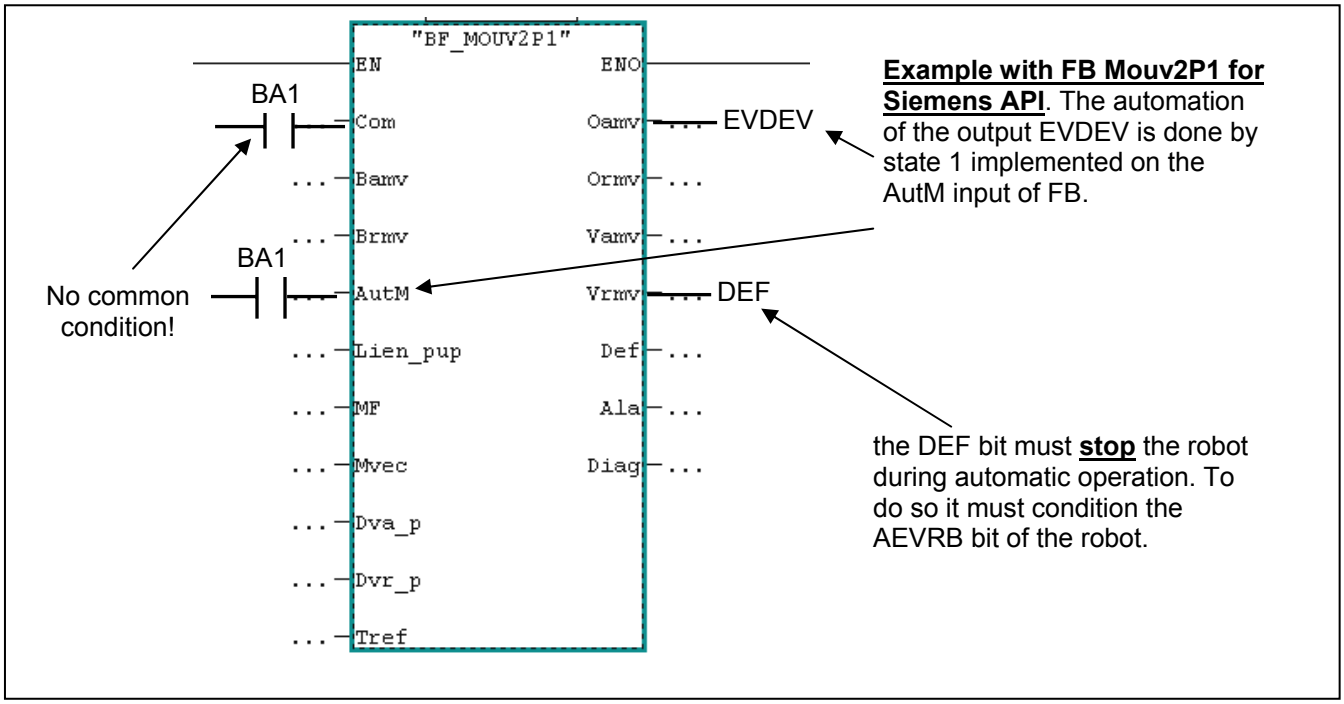
6.2.1 Changer Movement

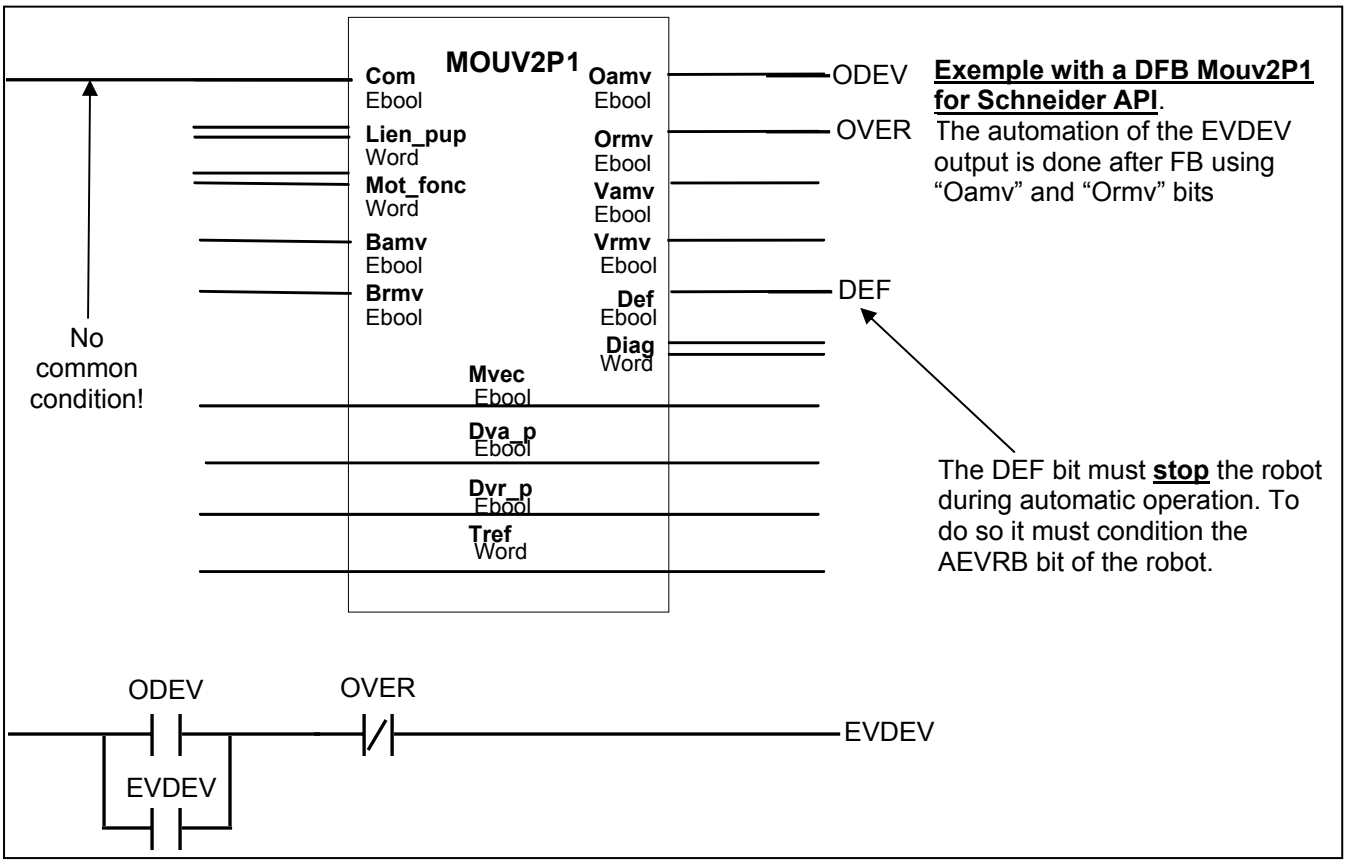
The COA controlling is ensured by the API through a BFR (Siemens) or DFB (Schneider) “MOUV2P1” from sequence 16.

In the same way that the physical output must have a permanent common 24V, it is important that the “COM” input of the BFR or DFB “Mouv2p1” is conditioned by no common. Positioned either a “bit to 1” or a direct command “stroke” on the COM input.

The command EV of the COA is a monostable EV, only unlocking is commanded and maintained. Locking is carried out by passage of the unlocking command to 0.

The information is collected either from the profinet framework of the robot or from the inputs and the output of the robot concerned in interbus.





6.2.2 Diagnosis changer

In order to ensure a better reliability of the changer, the PES company provides a chronogram and a list of defects to be permanently diagnosed by the automation.

A BFR for Siemens API and a DFB for Schneider API were created in order to simplify the program writing.

It is about:

the BFR No. 1836: "**BF_Diag_Coa**" whose implementation is explained in the document: **GE03.J0.045**

the DFB: "**Diag_Coa**"" whose implementation is explained in the document: **GE03.J0.044**

These two functional boxes make a defect bit available. This DEF bit must **stop** the robot during "automatic operation" mode. For that it is necessary to condition AEVRB bit of the robot.

The IHMP pages are dedicated to these defects.

6.2.3 API Plug-in

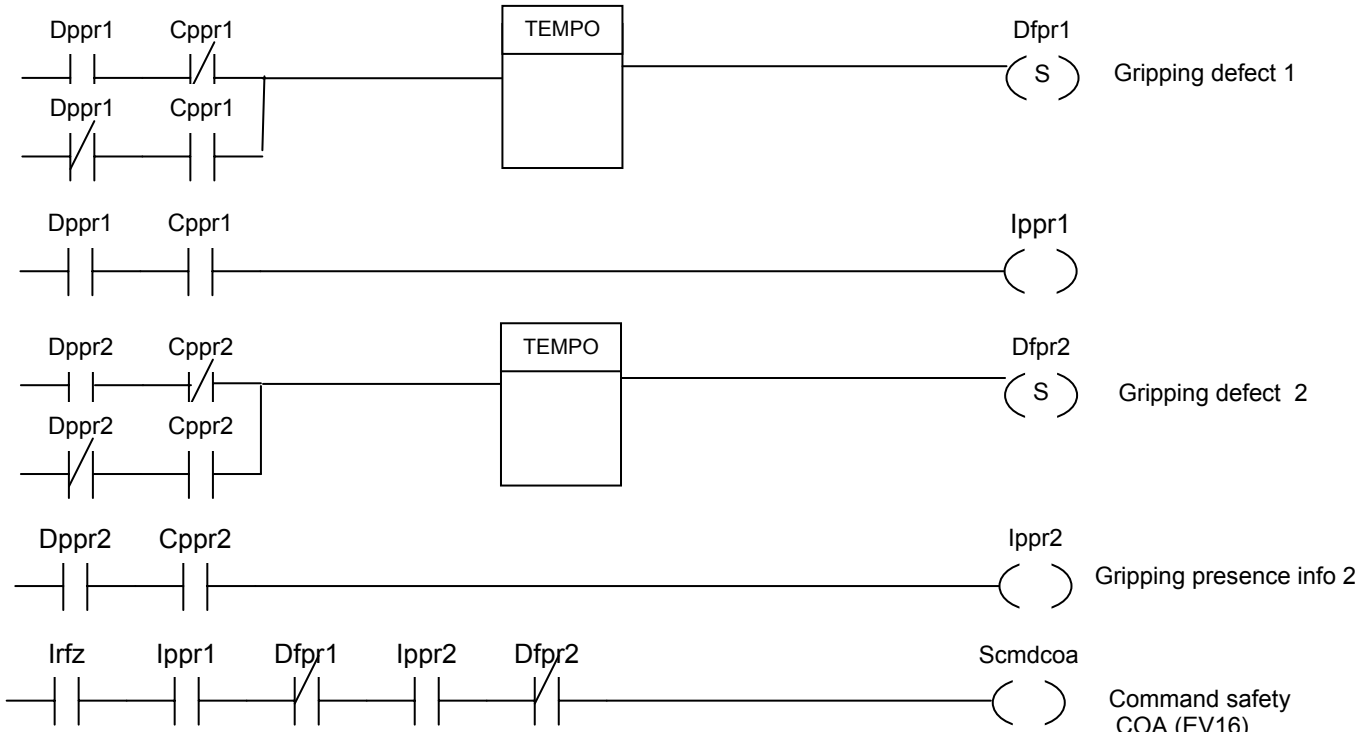
The Safety of the COA controlling is carried out by checking of the sensors (if there exists an inductive detector besides the electromechanical sensor) of presences in the placing locations. The API controls the presence of the tools in these locations as well as the consistency of information from these sensors. In the event of inconsistency, it generates a defect by placing location. Example with 2 tools:

- If there is only one tool in the placing locations, the other is on the carrier.
- If there is no tool in the placing locations, "tool X presence defect" is activated.
- So for a location, an inductive sensor is at 1 and the electromechanical sensor at 0 (and vice versa), "tool X presence consistency defect" is activated and must **stop** the robot in the mode "automatic operation". For that it is necessary to condition AEVRB bit of the robot.

When all the placing locations are occupied, without defect and that the zone is closed automatically, the API generates “CMD COA authorisation” information. This is assigned to a “robot event” (event 16) and is sent to the robot through the API/robot field network.

The API does not manage (manual control /command/controlling/MMI) the protection devices of the tools used.

Example of control with 2 tools: Cppr1 is the inductive detector (if necessary) and Dppr1 is the electromechanical sensor



6.3 Deactivation/reactivation network management

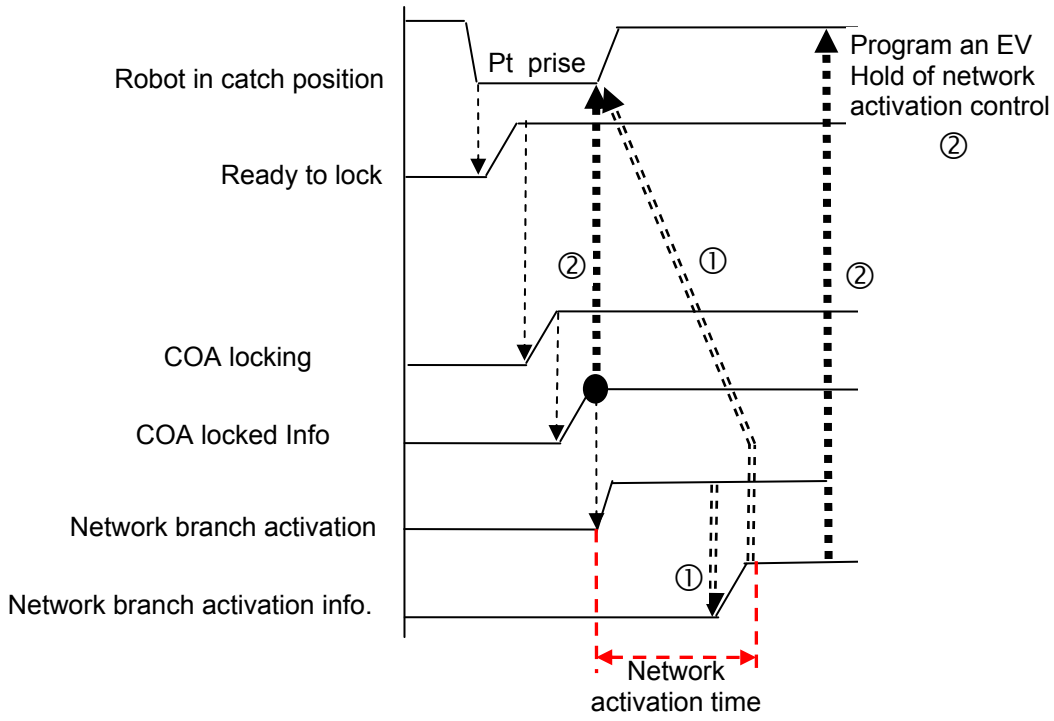
This function is necessary if the loaded tool is equipped with the network. It is used during the physical unlocking and locking of a tool on the COA. It carries out the deactivation and the “software” activation of the network branch according to the gripper.

For Siemens API, this feature is carried out by the API program through the standard BF “BF_act_desact” described in guide GE03 FP 215.

For Schneider API, this feature is carried out by the API program through the standard DFB “Ibs_act_desact” described in guide GE03 FP 183.

Example of connection chronogram:

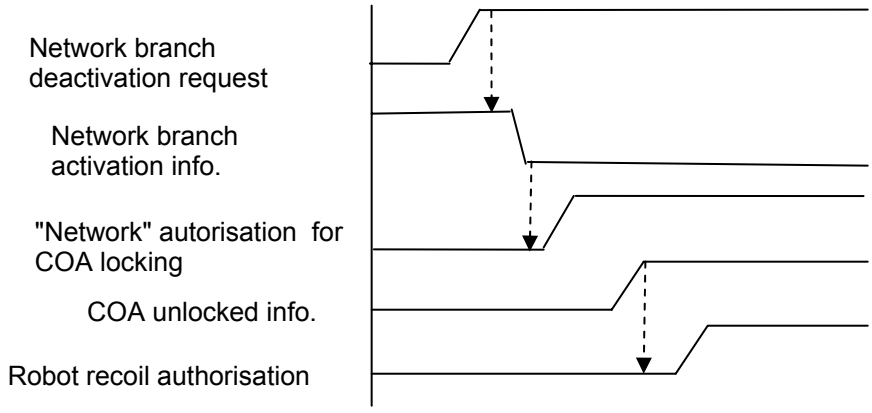
- Activation of the network modules coupled then controlling of the COA locking.



- Solution 1 (recommended): it is preferable to expect the network activation information before giving recoil authorisation to the robot.
- Solution 2: if the network activation time is too penalising for the machine cycle time, the recoil authorisation to the robot can be given as a locked COA information. The network activation control is carried out later in the machine cycle.

Example of chronogram in disconnection:

Deactivation network must be done before the changer unlocking



7 Robot movements and trajectories programs

The integrator creates one placing trajectory and one catch trajectory per tool. These trajectories according to the site requirements, will be integrated in one or more movement programs (Prog_MVT). They can also be registered individually in a specific prog_MVT making it possible to carry out independent placing and catch cycles (e.g.: to make a placing and return to the loopback without tool).

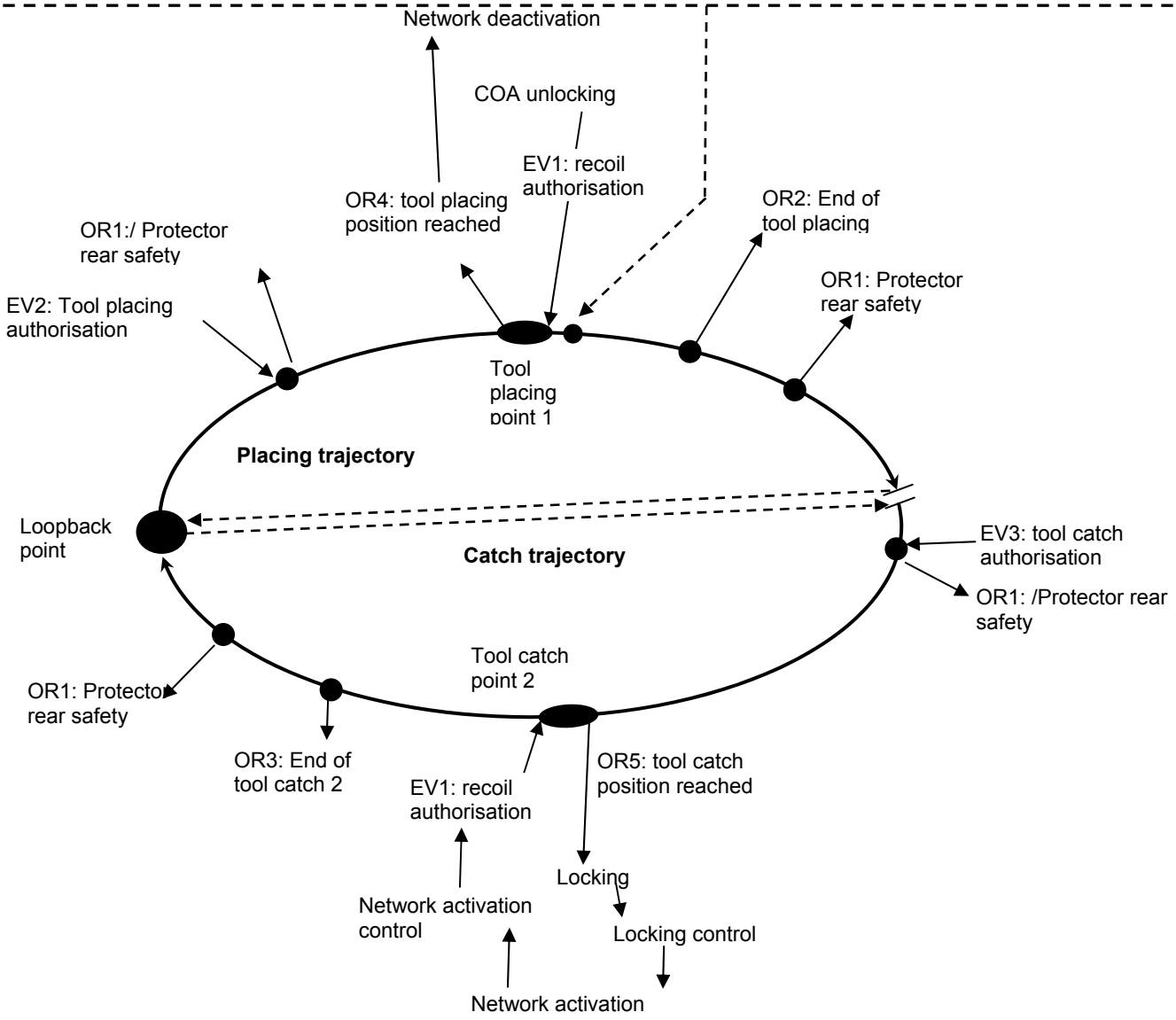
The protectors must be closed again after catch or placing, whether there is a tool present or not in the placing location (see chapter 2.4).

The diagrams below represent two examples of placing/catch trajectories of a tool gripper and welding gun. However, according to the number of placing positions, it is possible to use the same commands and events for all the tool change prog_MVT. The two examples can be mixed at the time of gun/gripper changer.

7.1 Example in gripper changer

Note: to avoid a start of the carrier with a tool remained "wedged" in the half-changer during placing, it is necessary:

- Either to control the "recoil authorisation" event in CTRL dynamic.
- Or to reprogram, just after the recoil of the carrier to the release of the changer, the "recoil authorisation" event in order to make sure that the tool did not remain "wedged" in the changer.



7.2 Example in SRE gun changer

On the placing trajectory it is necessary to program:

- the upstream water cut off maximum possible from the placing point (e.g.: after the pt_reb) in order to facilitate the decompression of water circuit.
- the deactivation of the welding gun through the dedicated instruction (see the integration guide of the manufacturer) upstream of the placing point. However, according to the manufacturers, this can be programmed on the placing point, but always before “tool placing position reached” command.

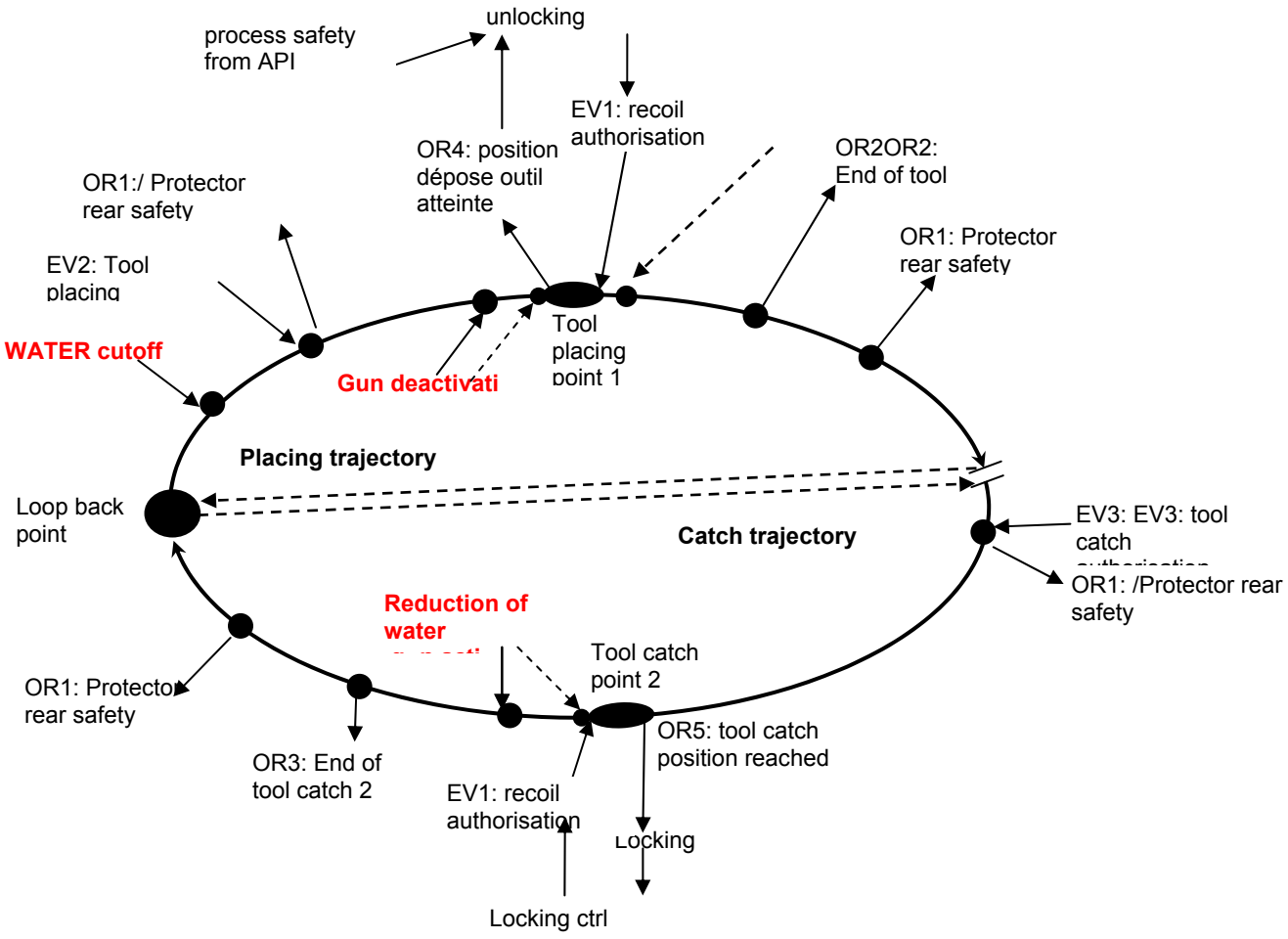
Note: One should not change the electrodes of a grip placeed in its transfer plate. In order to prevent a change electrodes this one must be placeed closed unconstrained.

On the trajectory of catch it is necessary to program:

- the reactivation of the grip to be welded via the instruction dedicated (see the guide of integration of the manufacturer) downstream from the point of catch. This one can be programmed on the point of catch, but always after the event “authorisation of recoil”.
- handing-over of water downstream from the point of catch.

Note: To avoid a start of the carrier with a tool remained “wedged” in the half-changer during placing, it is necessary:

- either to control the “recoil authorisation” event in dynamic CTRL.
- Or to reprogram after the tool placing position, the “recoil authorisation” event in order to make sure that the tool did not remain “wedged” in the changer.



8 Wiring and precautions of CEM implementation

Important:

In order to minimize the electromagnetic disruption risks which can involve long breakdowns, it is necessary to comply with the implementation rules of wiring network.

To do so, refer to the guide:

GE03.B0.026: Implementation guide for Equipotential connections and electromagnetic protection

GE03.C0.160: Implementation guide for PROFINET IO field network

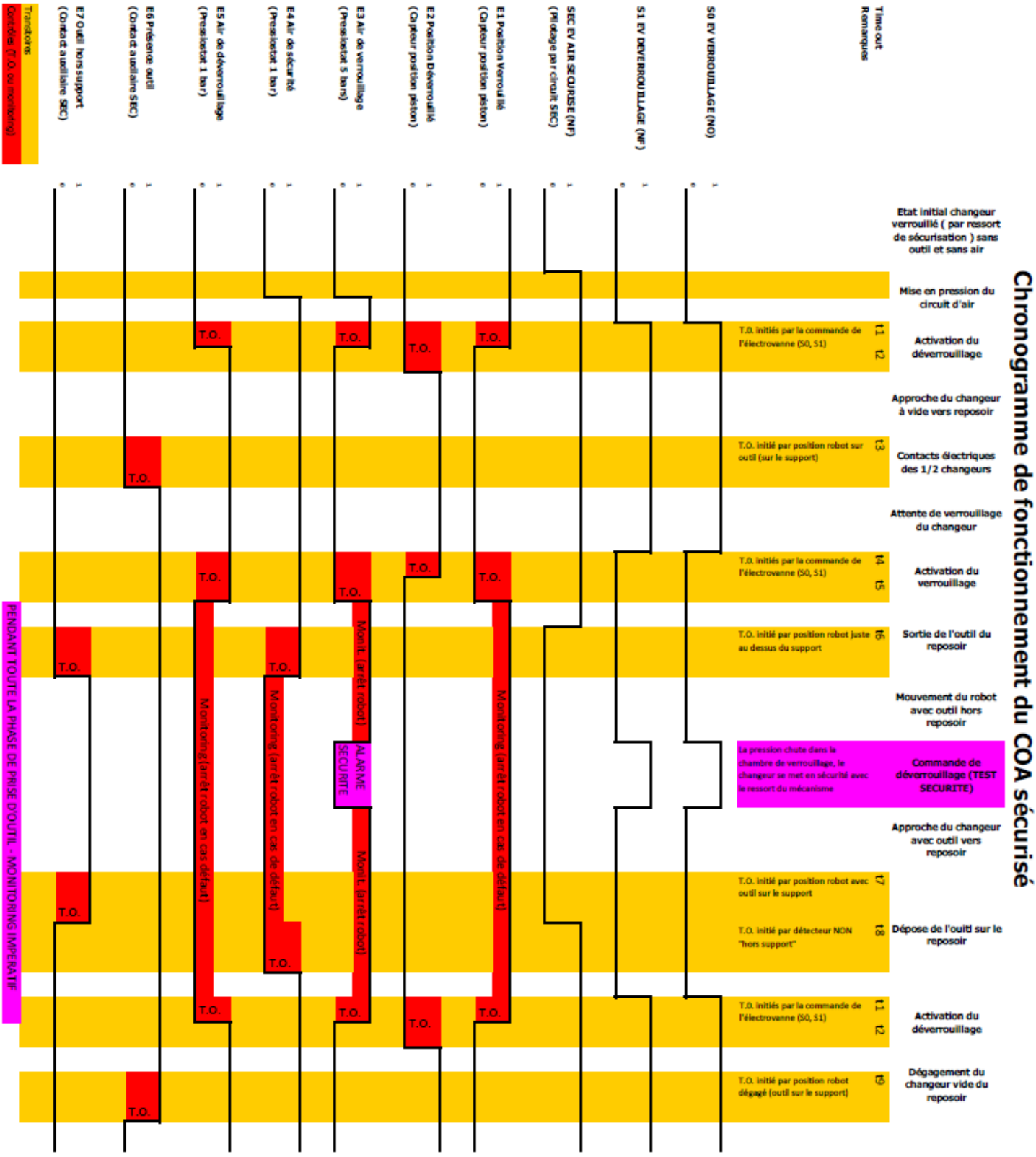
GE03.C0.018: Implementation guide for Interbus-S field network

These 3 guides describe these rules.

9 ANNEX

9.1 ANNEX 1: operation chronogram

Note: this chronogram and the principle described belong to the company PES.



9.2 ANNEX 2: List alarms

Note: this list and the principle described belong to the company PES.

Liste des alarmes pour le fonctionnement du COA sécurisé

Numéro d'alarme	Texte alarme	Type d'alarme	T.O.	Evènement enclencheur (Time Out) ou durée du monitoring	Capteur	Etat attendu capteur	Condition d'alarme	Test alarme (à réaliser avant la mise en service ou après toute modification software)
AL001	Pas de déverrouillage ou défaut position verrouillé	Time out	t1	Actionnement EV à 1 (S0, S1)	E1 - Position vérrouillé	0	(S0, S1 - Déverrouillage) ET TO(t1)	Forçage entrée E1 à 1
AL002	Pas de déverrouillage ou défaut position déverrouillé	Time out	t1+t2	Actionnement EV à 1 (S0, S1)	E2 - Position dévérrouillé	1	(S0, S1 - Déverrouillage) ET TO(t1+t2)	Forçage entrée E2 à 0 ou déconnecter capteur
AL003	Présence air verrouillage en déverrouillage ou défaut pressiostat air verrouillé	Time out	t1	Actionnement EV à 1 (S0, S1)	E3 - Air de verrouillage	0	(S0, S1 - Déverrouillage) ET TO(t1)	Forçage entrée E3 à 1
AL004	Absence air déverrouillage ou défaut pressiostat air déverrouillé	Time out	t1	Actionnement EV à 1 (S0, S1)	E5 - Air de déverouillage	1	(S0, S1 - Déverrouillage) ET TO(t1)	Forçage entrée E5 à 0 ou p<1bar
AL005	Pas de présence outil ou pas d'outil présent sur support ou défaut détecteur présence outil	Time out	t3	Position robot de contact	E6 - Présence outil	1	Position robot de contact sur support ET TO(t3)	Forçage entrée E6 à 0 ou pas d'outil
AL006	Pas de verrouillage sur outil ou défaut position verrouillé	Time out	t4+t5	Actionnement EV à 0 (S0, S1)	E1 - Position vérrouillé	1	(E6 - Présence outil) ET NO(S0/S1 - Déverrouillage) ET TO(t4+t5)	Forçage entrée E1 à 0 ou déconnecter capteur
AL007	Pas de verrouillage avec outil ou défaut position	Time out	t4	Actionnement EV à 0 (S0, S1)	E2 - Position dévérrouillé	0	(E6 - Présence outil) ET NO(S0/S1 - Déverrouillage) ET	Forçage entrée E2 à 1
AL008	Absence air verrouillage en verrouillage avec outil ou défaut pressiostat air verrouillé	Time out	t4+t5	Actionnement EV à 0 (S0, S1)	E3 - Air de verrouillage	1	(E6 - Présence outil) ET NO(S0/S1 - Déverrouillage) ET TO(t4+t5)	Forçage entrée E3 à 0 ou p<5bars
AL009	Présence air déverrouillage en verrouillage avec outil ou défaut pressiostat air déverrouillé	Time out	t4+t5	Actionnement EV à 0 (S0, S1)	E5 - Air de déverouillage	0	(E6 - Présence outil) ET NO(S0/S1 - Déverrouillage) ET TO(t4+t5)	Forçage entrée E5 à 1
AL010	Présence air sécurisé avec outil ou défaut pressiostat air sécurité	Time out	t6	Position robot au-dessus support	E4 - Air sécurité	0	Position robot au dessus du support ET TO(t6)	Forçage entrée E4 à 1
AL011	Position robot pas hors support ou défaut détecteur outil hors support	Time out	t6	Position robot au-dessus support	E7 - Outil hors support	1	Position robot au dessus du support ET TO(t6)	Forçage entrée E7 à 0 ou position robot
AL012	Perte de verrouillage sur outil ou défaut position verrouillé	Monitoring	NA	((E6 - Présence outil) ET (E7 - Outil hors support)) OU Memo "robot avec outil et hors support" *	E1 - Position vérrouillé	1	E1 - Position vérrouillé = 0 (ARRET IMMEDIAT ROBOT - DANGER)	Forçage entrée E1 à 0 et test déconnecter capteur
AL013	Absence air verrouillage en verrouillage avec outil ou défaut pressiostat air verrouillé	Monitoring	NA	((E6 - Présence outil) ET (E7 - Outil hors support)) OU Memo "robot avec outil et hors support" *	E3 - Air de verrouillage	1	E3 - Air de verrouillage = 0 (ARRET IMMEDIAT ROBOT - DANGER)	Forçage entrée E3 à 0 et test p=4bars
AL014	Présence air sécurisé avec outil ou défaut pressiostat air sécurité	Monitoring	NA	((E6 - Présence outil) ET (E7 - Outil hors support)) OU Memo robot avec outil et hors support *	E4 - Air sécurité	0	E4 - Air sécurité = 1 (ARRET IMMEDIAT ROBOT - DANGER)	Forçage entrée E4
AL015	Présence air déverrouillage en verrouillage avec outil ou défaut pressiostat air déverrouillé	Monitoring	NA	((E6 - Présence outil) ET (E7 - Outil hors support)) OU "Memo robot avec outil et hors support" *	E5 - Air de déverouillage	0	E5 - Air déverrouillage = 1 (ARRET IMMEDIAT ROBOT - DANGER)	Forçage entrée E5
AL017	Position robot de dépose hors support ou défaut détecteur outil hors support	Time out	t7	Position robot pour dépose sur support	E7 - Outil hors support	0	Position robot de dépose sur support ET TO(t7)	Forçage entrée E7 à 1 ou position robot
AL018	Absence air sécurisé avec outil sur support en dépose ou défaut pressiostat air sécurité	Time out	t8	Entrée E7 (hors support) passe à zéro	E4 - Air sécurité	1	Position robot de dépose sur support ET TO(t8)	Forçage entrée E4 à 0
AL019	Présence outil (reste accroché) ou position robot pas hors support ou défaut détecteur présence outil	Time out	t9	Position robot au-dessus support	E6 - Présence outil	0	Position dégagement robot sur support ET TO(t9)	Forçage entrée E6 à 1 ou position robot

*** Memo robot avec outil et hors support : à réaliser suivant séquence du robot**