



Door interlocking for distributed control panels

Circuit diagram, bill of materials
and functional sequence

Application solution I V2.0

Electrical door interlock according to UL 508A and NFPA 79

In this application example, we show you how to comply with the requirements of the US standards for mechanical/electronic door interlocks of distributed control panels with any number of doors, while at the same time saving effort and costs.



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Application examples – legal information

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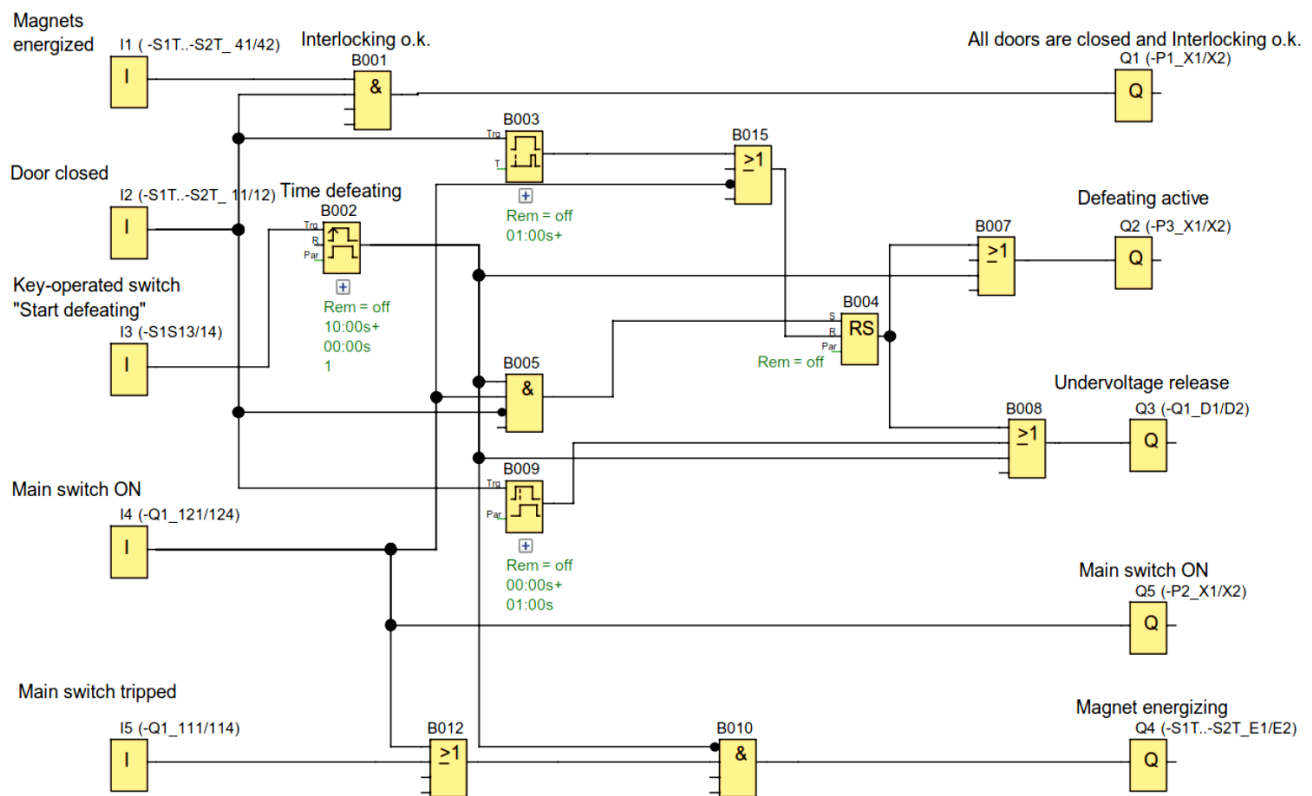
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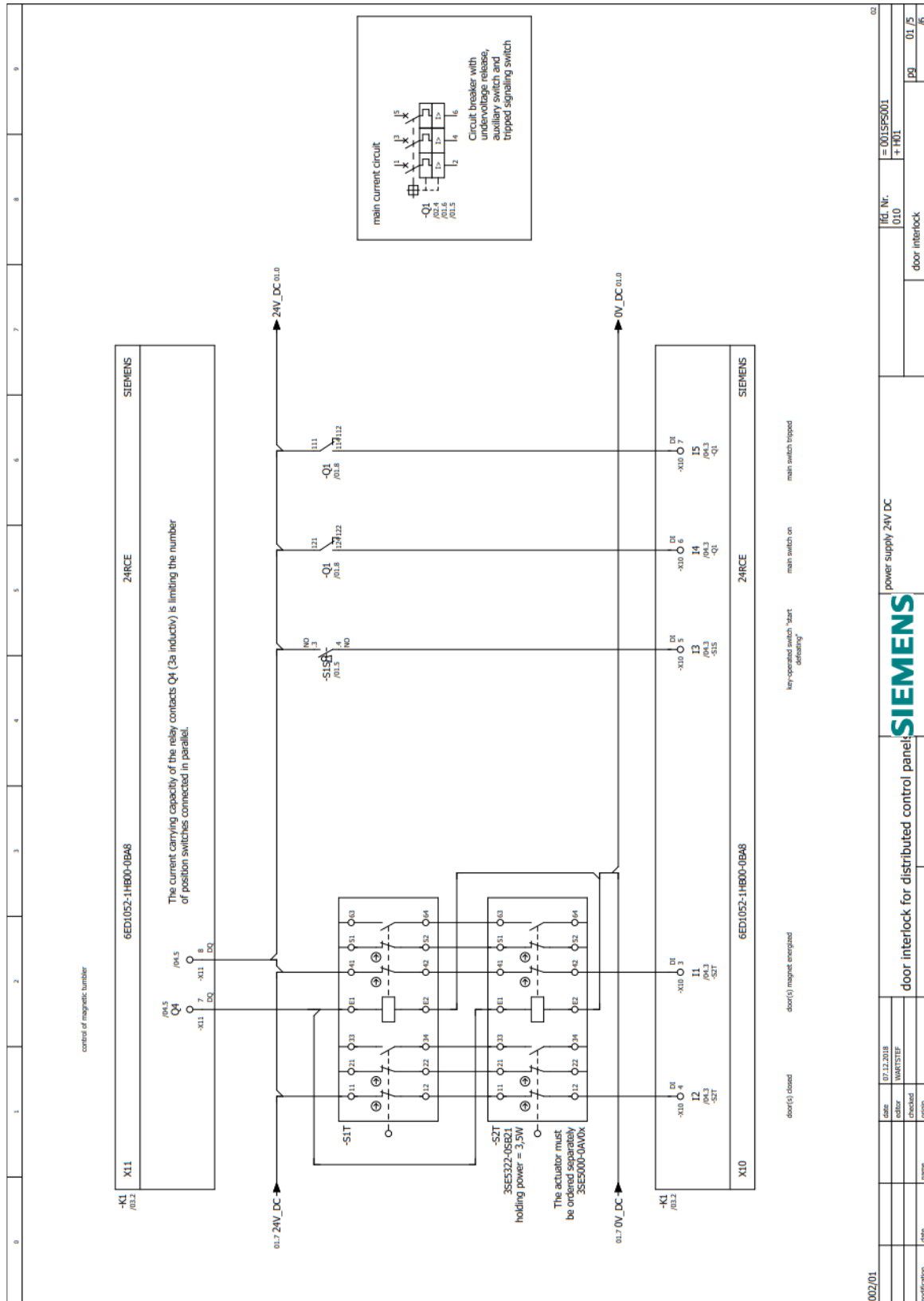
1. Electronic door interlocking with LOGO!

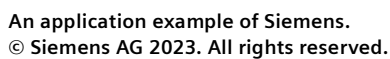
Circuit diagram, bill of materials and functional sequence

Overview of door interlocking with LOGO!

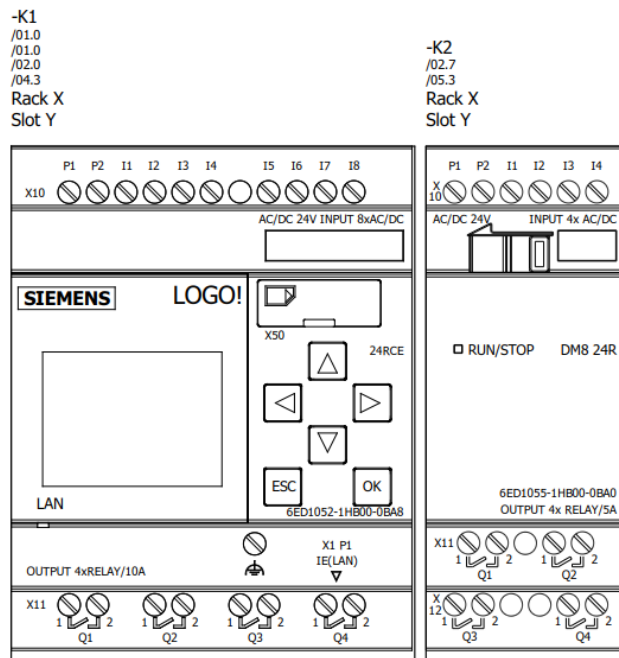


Door interlocking circuit diagram



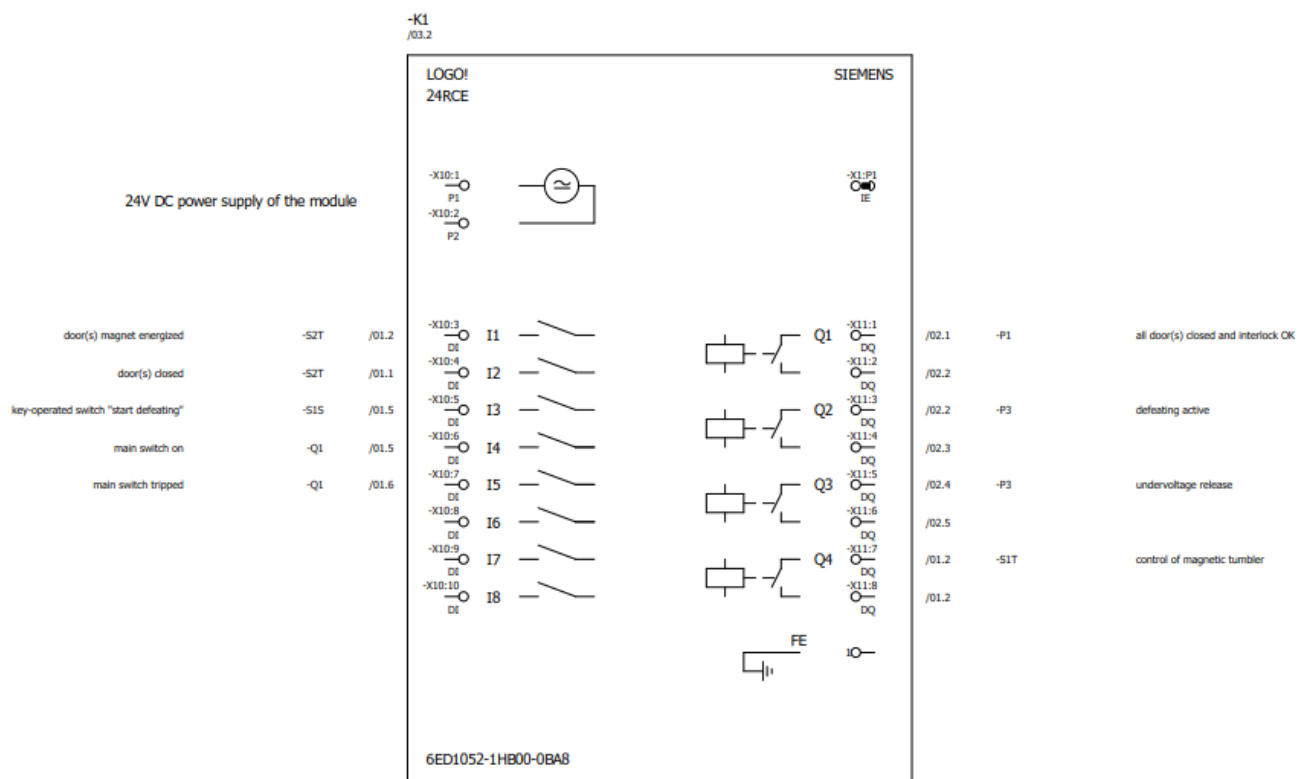


PLC overview LOGO! controller

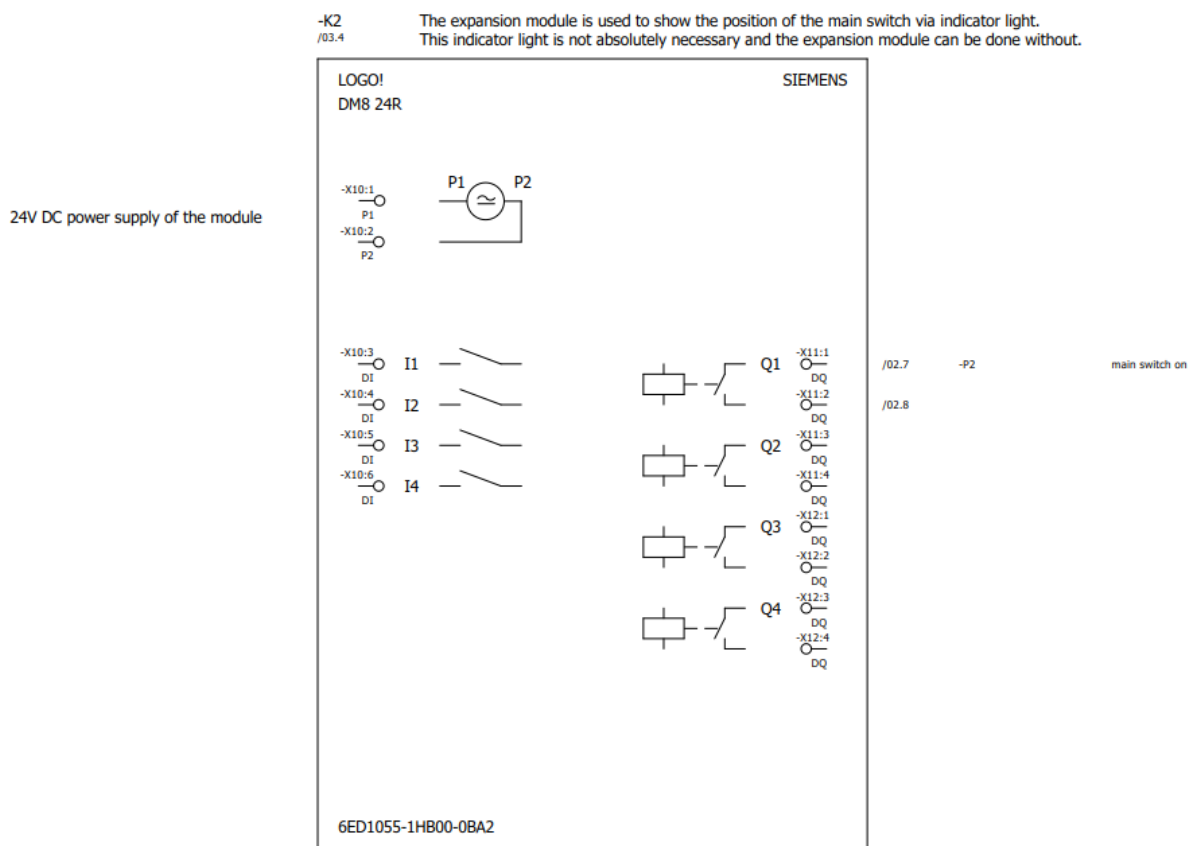


The expansion module is used to show the position of the main switch via indicator light.
This indicator light is not absolutely necessary and the expansion module can be done without.

PLC overview LOGO! controller inputs and outputs



PLC overview LOGO! controller inputs and outputs



Bill of materials

Label	Quantity	Designation	Technical specifications	Type number
-K1	1	Logic module LOGO! 24 RCE ¹⁾	8DI 24 V AC/DC 4 relay outputs 10 A	6ED1052-1HB08-0BA0
-K2	1	LOGO! DM8 24R ²⁾	4DI 24 V AC/DC 4 Relay outputs 5 A	6ED1055-1HB00-0BA2
-P1	1	Light element	24 V AC/DC; BA9s; green	3SU1152-6AA40-1AA0
-P1	1	Label holder	Black	3SU1900-0AN10-0AA0
-P2	1	Light element	24 V AC/DC; BA9s; green	3SU1152-6AA40-1AA0
-P2	1	Label holder	Black	3SU1900-0AN10-0AA0
-P3	1	Light element	24 V AC/DC; BA9s; red	3SU1152-6AA20-1AA0
-P3	1	Label holder	Black	3SU1900-0AN10-0AA0
-Q1	1	Main switch		3VA5215-6EC31-0AA0
-Q1	1	Undervoltage release		3VA9978-0BB11
-Q1	1	Auxiliary switch (changeover contacts)		3VA9978-0AA12
-Q1	1	Tripped alarm switch (changeover contacts)		3VA9978-0AB12
-Q1	1	Door-coupling rotary operating mechanism complete		3VA9277-0FK31
-Q1	1	Additional handle for door coupling rotary operating mechanism		3VA9477-0GC01
-S1S	1	Key-operated switch 2 positions	0-1; momentary contact type	3SU1050-4BC01-0AA0
-S1S	1	Label holder	Black	3SU1900-0AN10-0AA0
-S1S	1	Switching element	1S; Front	3SU1400-1AA10-1BA0
-S1T	1	Position switch	24 V DC; with tumbler	3SE5322-0SB21
-S2T	1	Position switch	24 V DC; with tumbler	3SE5322-0SB21

¹⁾As an alternative to the LOGO! basic module (-K1), a LOGO! without display could also be used. Optionally, a LOGO! text display can be installed instead of the indicator lights.

Adjustments then have to be made in the program for this purpose.

The following messages, for example, could be generated in this case:

- Main switch tripped
- Error in the position switch magnetic hold circuit
- Error in the position switch actuator circuit
- etc.

Adjustments then have to be made in the program for this purpose.

²⁾If no "Main switch ON" (-P2) message is needed, the expansion module can be omitted.

Functional sequence of mechanical/electronic door interlocking

This procedure describes the mode of operation of mechanical/electronic (LOGO! "Black Box") door interlocking as per UL508A / NFPA 79 according to this circuit diagram.

1. The main switch (-Q1) with door coupling rotary drive and second handle according to UL508 A / NFPA 79 mechanically interlocks the door that is connected to the main switch.
2. The position switches with magnetic tumbler (-S1T to -S2T) interlock the remaining control cabinet doors electrically.
3. The main switch is mechanically defeated using a tool at the handle of the door coupling rotary drive so that the door can be opened by specialist personnel when the main switch is switched on.
4. The doors, which are electrically interlocked with the position switches, are defeated by an "electrical" actuation so that they can also be opened by specialist personnel when the main switch is switched on.
5. Operation of the "electrical" defeat function:
 - a) The magnets of the position switches can be unlocked by means of block B02 (interval time-delay relay, edge-triggered) for 10 seconds using the key switch (-S1S).
 - b) If no door is opened in this period (i.e. the actuators of the position switches remain interlocked) the magnets are energized again after 10 seconds and the doors remain interlocked.
 - c) If a door or several doors are opened during this time, all magnets of the position switches are energized again after 10 seconds and the doors that are not open remain interlocked.
 - d) When an open door is closed again, the actuator interlocks automatically with the magnet already energized.
6. When the main switch is switched OFF, all doors are unlocked and can be opened. However, if the main switch is switched back ON and one or more doors of the electrical interlock are still open, the main switch is tripped by the undervoltage release and falls into the "Trip" position. If this is to be avoided (due to maintenance), the defeat function must be started before the main switch is switched ON again with open door(s).
7. If the main switch is tripped, e.g. by an overload or a short circuit, the doors remain interlocked. The doors are opened either by starting the electrical defeat function or by switching the main switch to the OFF position.
8. Explanation of indicator lights:
 - a) -P1 → "All doors are closed and interlocked" means that the magnets are energized and the actuators are plugged in
 - b) -P2 → "Main switch ON" means that the main switch is engaged.
 - c) -P3 → "Defeating active" means that the electrical defeat function is active

Notes on electronic door interlocking

1. Block B02 (interval time-delay relay) is edge-triggered. Any time can be selected.
2. Block B03 (ON delay) has a switch-on delay (1 sec.) and block B09 (switch-on/off delay) has a switch-on delay (0 sec.) and switch-off delay (1 sec.). These delays should ensure that when the defeat function is started and subsequently ended, the undervoltage releases from the main switch (-Q1) do not inadvertently trip this switch.
3. If an error should occur in the actuator circuit from the position switch (e.g. wire break of actuator circuit), door interlock safety is no longer provided and the main switch (-2Q1) trips by means of its undervoltage release!
4. If a magnet of the position switches fails, the main switch (-Q1) does not trip! This can also be seen from the fact that the light indicator "All doors are closed and interlocked" (-P1) is off. However, if such a door with a defective magnet of the position switch is opened without the electrical defeat function being active, the main switch also trips and does so via the actuator circuit. Door interlock safety is thus provided. This was chosen so as not to unnecessarily interrupt operations and the process.

Notes on mechanical door interlocking

1. The door of the main switch is opened beyond the "Off" position with "Door Open" position.

2. A tool on the handle can be used to open the door when the main switch is switched on.
3. It is possible to switch on the main switch when the door is open using a "deliberate action" with the second handle on the main switch.
4. When the main switch and the handle in the door are in the "ON" position, door interlocking automatically becomes effective again when the door closes.

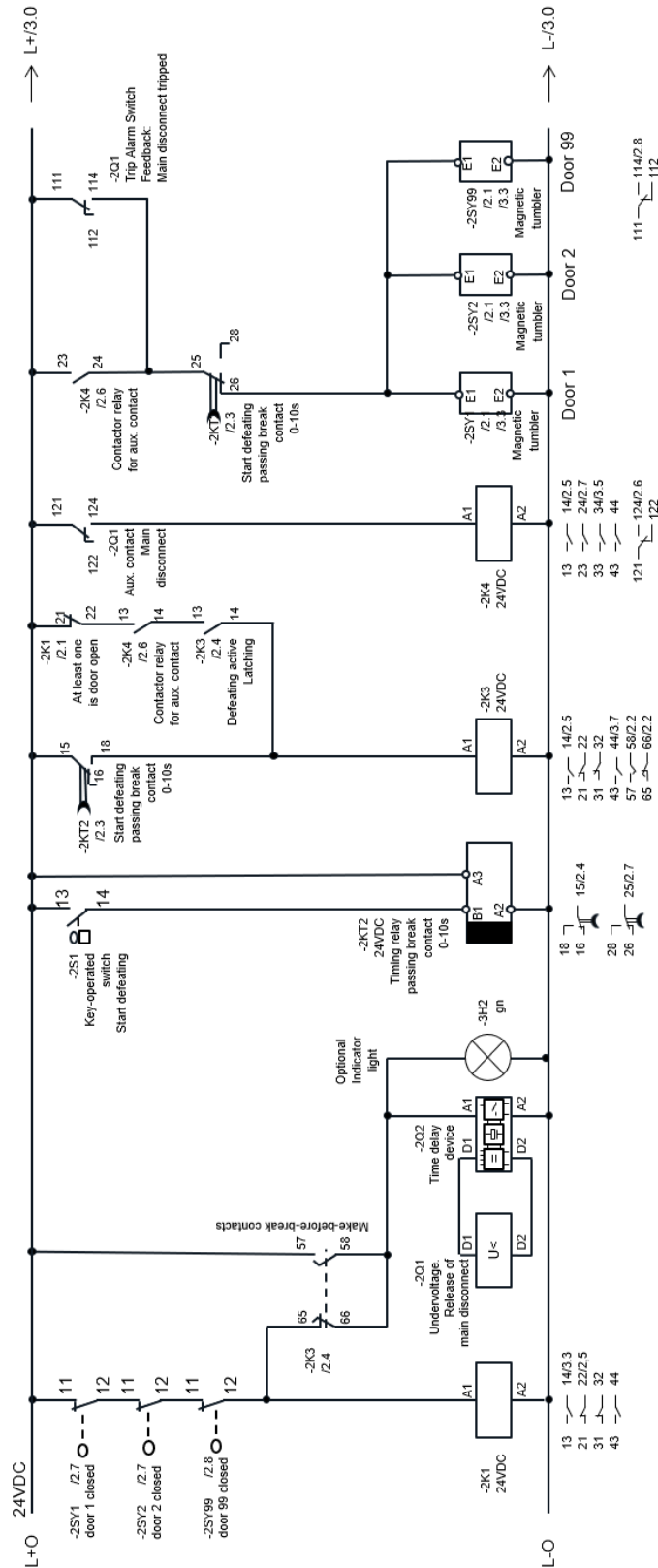
Notes on indicator lights

It may be possible to dispense with the "Main switch ON" indicator, as the switch position is visible from the position of the second handle on the switch when the door is open, or the position on the door handle when the door is closed. The LOGO! expansion module could therefore be done without.

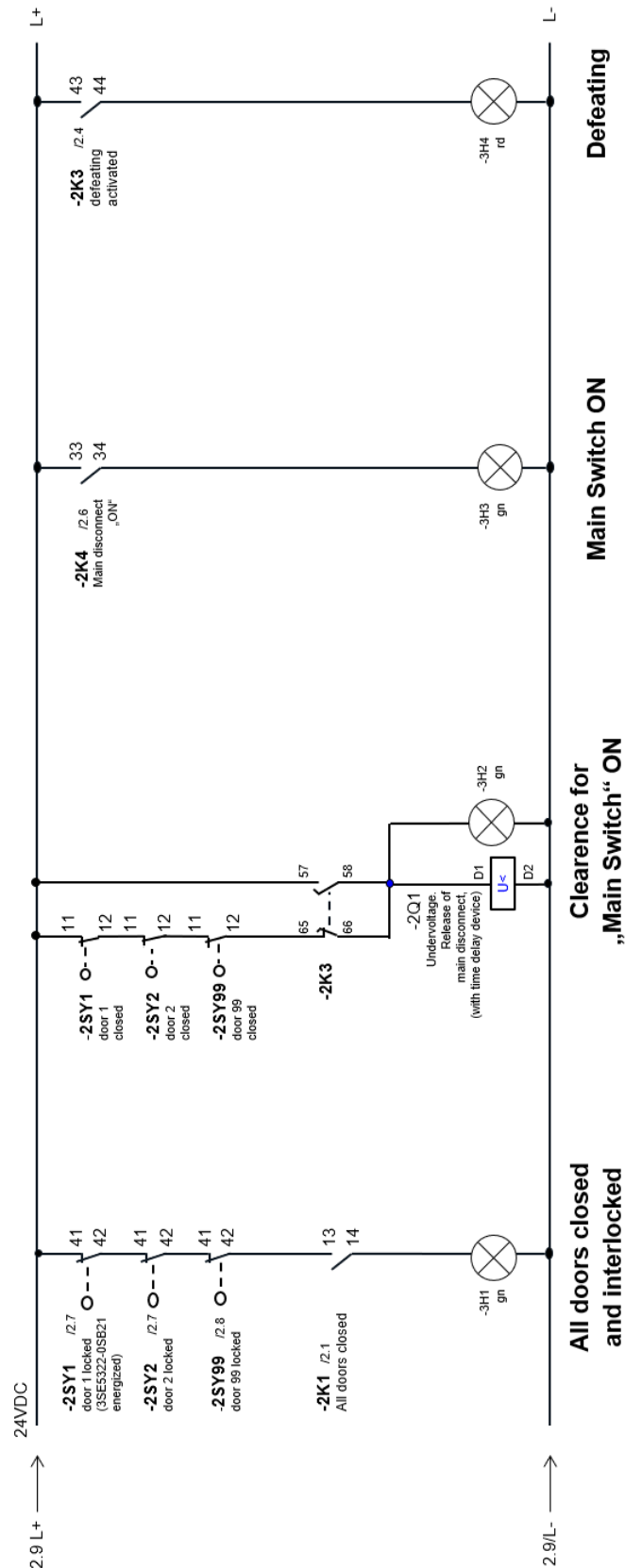
2. Electric door interlocking

Circuit diagram, bill of materials and functional sequence

Circuit diagram of the door interlocking



Circuit diagram of indicator lights



Bill of materials

Kennzeichen	Menge	Bezeichnung	Technische Spezifikation	Typnummer
-3H1, -3H2, -3H3	3	Light indicator	LED; 24V AC/DC; green	3SU1152-6AA40-1AA0
-3H4	1	Light indicator	LED; 24V AC/DC; red	3SU1152-6AA20-1AA0
-3H1, -3H2, -3H3, -3H4, 2S1	5	Labeling plate	Black	3SU1900-0AN10-0AA0
-2K1	1	Contactor relay (Feedback contactor)	2NO+2NC; 24V DC	3RH2122-1BB40
-2K3	1	Contactor relay (Reversing contactor)	2NO+2NC; 24V DC	3RH2122-1BB40
-2K3	1	Auxiliary switch block with make-before-break contactor		3RH2911-1FB11
-2K4	1	Contactor relay (interlocking contactor)	4NO; 24V/DC	3RH2140-1BB40
-2KT2	1	Timing relay	Multifunction; 2CO; 24V DC	3RP2505-1BB30
-2S1	1	Key-operated switch 2 positions	0-1; momentary contact type	3SU1050-4BC01-0AA0
-2S1	1	Contact module	1NO; front	3SU1400-1AA10-1BA0
-SY1, -SY2, ... -SY99	1-99	Position switch "Solenoid-locked" (Number of locking doors)	24V DC; with tumbler	3SE5322-0SB21
-2Q1	1	1 Machine supply circuit disconnect 1 Undervoltage releases UVR 1 Auxiliary switch AUX 1 Trip alarm switches TAS		3VA5215-6EC31-0AA0 3VA9978-0BB11 3VA9978-0AA12 3VA9978-0AB12
-2Q1	1	Door mounted rotary operator (complete)	Suitable for 3VA52, 3VA61 and 3VA62	3VA9277-0FK31
-2Q1	1	Supplementary handle (NFPA79)		3VA9477-0GC01
-2Q1	1	Time-delay devices for undervoltage releases	24V DC	3VA9978-0BF23



Machine supply circuit
disconnect 3VA5



Door mounted rotary operator
(complete)



Supplementary handle
(NFPA79)



Time-delay devices for
undervoltage releases

Functional sequence of mechanical / electrical door interlocking

The purpose of this sequence is to describe the operating principle of a mechanical/electrical door interlocking according to UL 508A/ NFPA 79 based on this circuit diagram.

1. The main switch (-2Q1) with door-coupling rotary operating mechanism and second handle according to UL 508A/NFPA 79 mechanically interlocks the door, which is connected to the main switch.
2. The position switches with magnetic tumbler (-2SY1... to 2SYx) interlock the remaining control cabinet doors electrically.
3. The main switch is mechanically defeated with a tool on the handle of the door-coupling rotary operating mechanism so that the door can be opened by specialist personnel when the main switch is closed.
4. The doors, which are electrically interlocked with the position switches, are defeated by an "electrical" actuation, so that they can also be opened by specialist personnel when the main switch is closed.
5. Operator control of "electrical" defeat function:
 - a) Using key-operated switch (-2S1), unlocking of the magnets of the position switches, here for 10 seconds, is enabled via the time relay (-2KT2, breaking-pulse interval relay).
 - b) If no door is opened during this time, (i.e. the actuators of the position switches remain interlocked), the magnets are supplied with current again after 10 seconds and the doors remain interlocked.
 - c) If a door (one or more) is opened during this time, the magnets of the position switches are supplied with current again after 10 seconds and the unopened doors remain interlocked.
 - d) If an open door is closed again, the actuator is automatically interlocked again with the magnets that have already been supplied with current.
6. When the main switch is switched off, all doors are unlocked and can be opened. However, if the main switch is closed again and one or more doors of the electrical interlock are still open, the main switch is tripped by the undervoltage trip unit and falls into the "Trip" position. If this is to be prevented (maintenance-related), the defeating function must be started before the main switch is switched on again when any doors are open.
7. If the main switch is tripped, e.g. by an overload or a short-circuit, the doors remain interlocked. The doors are opened either by starting the electrical defeat function or by switching the main switch to OFF position.
8. Explanation of the indicator lights
 - a) -3H1 → "All doors are closed and interlocked" means that the magnets are supplied with current and the actuators are inserted
 - b) -3H2 → "Main switch ON" means that the main switch is engaged
 - c) -3H3 → "Defeating function active" means that the electrical defeating function is active

Comments regarding the electrical door interlocking

1. The time relay (-2KT2) is designed as a breaking-pulse interval relay. The time can be freely selected.
2. The contactor (-2K3) has, among other things, two overlapping contacts. These overlapping contacts and the delay device (-2Q2) should guarantee that, on start of the defeat function and subsequent ending of the defeat function of the undervoltage trip of the main switch (-2Q1), the main switch is not unintentionally tripped.
3. If a fault occurs in the actuator circuit of the position switch (e.g. wire break in actuator circuit), door interlock safety is no longer provided and the main switch (-2Q1) trips by means of its undervoltage trip!
4. If a magnet of the position switches fails, the main switch (-2Q1) does not trip! This can also be recognized by the fact that the indicator light "All doors are closed and interlocked" (-3H1) is off. However, if a door with a defective magnet of the position switch is opened when the electric defeat function is not activated, the main switch also trips and, namely, via the actuator circuit. Door interlock safety is thus also provided here. This was therefore selected in such a way to avoid unnecessary interruption of the operating sequence and the process.

Comments regarding the mechanical door interlocking

1. The door of the main switch is opened beyond the "Off" position with "Door Open" position.
2. The opening of the door when the main switch is switched on can be defeated with a tool at the handle.

3. A closing of the main switch when the door is open is possible with a "deliberate operation" using the second handle at the main switch.
4. When the main switch is in position "ON" and the handle is in the door, the door interlock automatically becomes operative again when the door is closed.

Comments regarding the indicator lights

The indicator light "Main switch ON" can possibly be omitted because the switch position is apparent from the position of the second handle on the switch when the door is open or the position on the door handle when the door is closed.

3. Electronic door interlocking with SIMATIC

Overview, parts list and program block

Overview of door interlocking with program block SIMATIC STEP 7 V15.1

Functional sequence for mechanical/electronic door interlocking

This sequence describes the operation method of a mechanical/electronic (SIMATIC "black box") door interlocking acc. to UL508A / NFPA 79 in the available function block.

1. The main switch (-Q1) with door-coupling rotary operating mechanism and second handle acc. to UL508 A / NFPA 79 mechanically interlocks the door that is connected to the main switch.
2. The position switches with magnet locking device interlock the other control panel doors electrically.
3. The main switch is mechanically defeated at the handle of the door-coupling rotary operating mechanism with a tool, so that the door can be opened by qualified personnel when the main switch is turned on.
4. The doors that are electrically interlocked with the position switches are defeated by "electrical" operation so that they can be opened by qualified personnel even when the main switch is turned on.
5. Operator control of "electrical" defeating function:
 - a) Using a key-operated pushbutton (-S1S), unlocking of the magnets of the position switches is enabled. The time window for this operation is 10 seconds.
 - b) If no door is opened within this time (i.e. the actuators of the position switches remain locked), the magnets are energized again after 10 seconds and the doors remain locked.
 - c) If one or more doors are opened during this time, all magnets of the position switches are energized again after 10 seconds and the unopened doors remain locked.
 - d) If an open door is closed again, the actuator is automatically locked again with the already energized magnet.
6. If the main switch is switched off, all doors are unlocked and can be opened. However, if the main switch is turned on again while one or more doors of the electrical interlocking are still open, the main switch is tripped by the undervoltage release and drops into the tripped position. If this must be prevented (for maintenance reasons),

defeating must be started before the main switch is turned on again while one or more doors are open.

7. If the main switch is tripped, e.g., by an overload or a short-circuit, the doors remain locked. The doors are opened either by starting the electrical defeating function or by putting the main switch into the OFF position.
8. Explanation of the indicator lights:
 - a) -P1 → "All doors are closed and locked" means that the magnets are energized and the actuators are inserted.
 - b) -P2 → "Main switch ON" means that the main switch is closed.
 - c) -P3 → "Defeating active" means that the electrical defeating function is active.

Comments on the mechanical door interlocking

1. The door of the main switch is opened beyond the "Off" position with "Door Open" position.
2. The opening of the door when the main switch is closed can be defeated with a tool at the handle.
3. Closing the main switch when the door is open is possible with a "deliberate action" by means of the second handle at the main switch.
4. When the main switch is in the "ON" position and the handle is in the door, the door interlocking automatically becomes operative again when the door is closed.

Comments on the indicator lights

The indicator light for "main switch ON" may not be necessary because the switch position is visible by the position of the second handle at the switch when the door is open or by the position at the door handle when the door is closed.

Appendix description of program block

Function block
Tag list
Networks

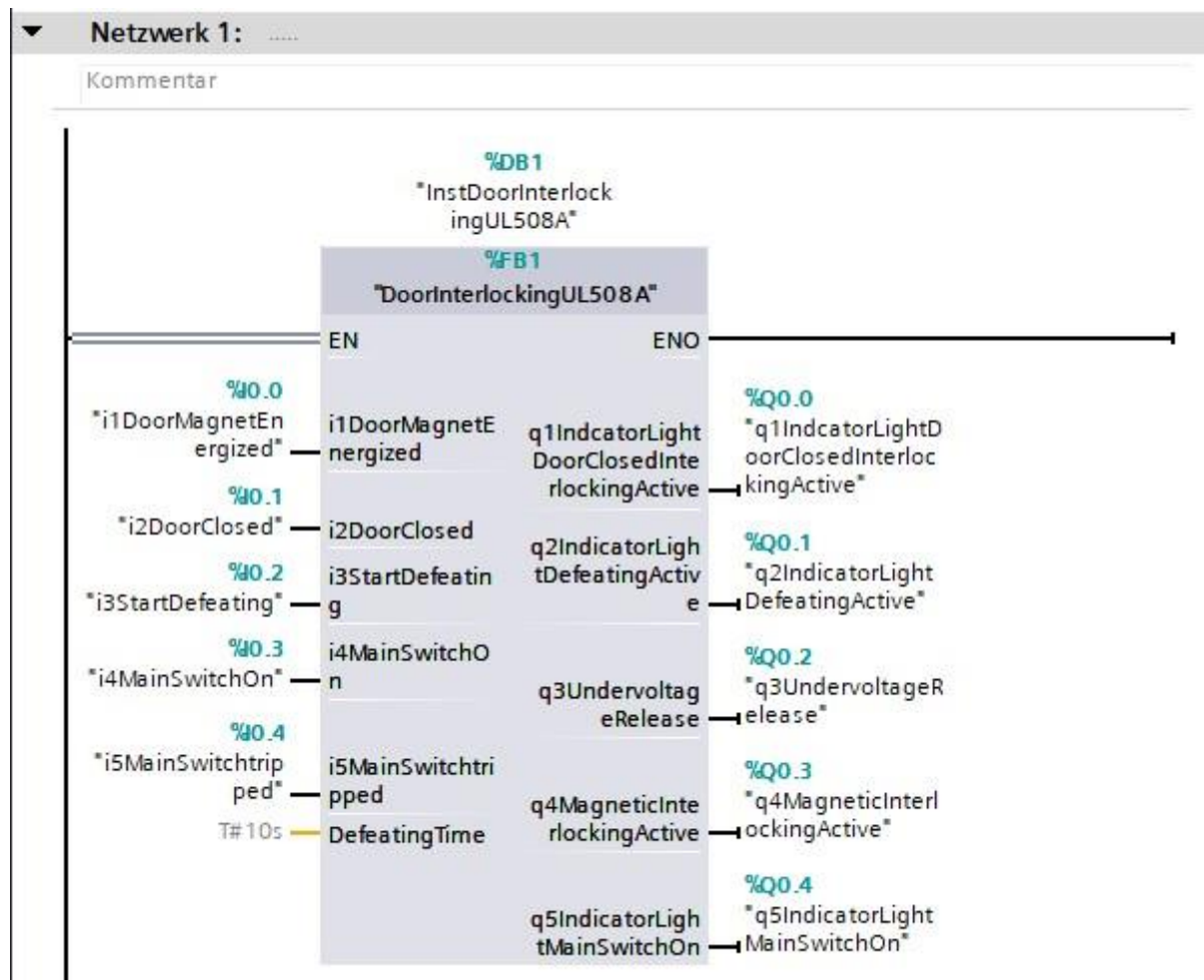
Parts list of the components used

Code	Quantity	Designation	Technical specification	Type number
	1	SIMATIC S7-1200/1500 controller	can be programmed with STEP7 V15.1 and higher	
-Q1	1	Main switch	Rated current according to requirement	3VA5/6...
-Q1	1	Door-coupling rotary operating mechanism	with door tumbler (locking device) and door opening function	3VA9...
-Q1	1	Supplementary handle	for switching on with the door open	3VA9...
-Q1	1	Undervoltage release	24 V DC	3VA9978-0BB11
-Q1	1	Auxiliary contact trip alarm	1CO	3VA9978-0AB12
-Q1	1	Auxiliary contact	1CO	3VA9978-0AA12
-P1	1	Light element	Indicator light green LED 24 V DC	3SU1152-6AA40-1AA0
-P1	1	Label holder	Black	3SU1900-0AN10-0AA0
-P2	1	Light element	Indicator light green LED 24 V DC	3SU1152-6AA40-1AA0
-P2	1	Label holder	Black	3SU1900-0AN10-0AA0
-P3	1	Light element	Indicator light red LED 24 V DC	3SU1152-6AA20-1AA0
-P3	1	Label holder	Black	3SU1900-0AN10-0AA0
-S1S	1	Key-operated button 2 positions	0-1; momentary contact type	3SU1050-4BC01-0AA0
-S1S	1	Label holder	Black	3SU1900-0AN10-0AA0
-S1S	1	Contact block	1NO; front	3SU1400-1AA10-1BA0
	n	Position switch	24 V DC; with locking device	3SE5322-0SB21
		Number corresponding to the doors		

Program blocks

Totally Integrated Automation Portal

EnclosureInterlockingUL508Aen ▶ PLC [CPU 1211C AC/DC/Rly] ▶ Programmbausteine ▶ Main [OB1]				
Main				
	Name	Datentyp	Defaultwert	Kommentar
1	▼ Input			
2	Initial_Call	Bool		Initial call of this OB
3	Remanence	Bool		=True, if remanent data are available
4	▼ Temp			
5	<Hinzufügen>			
6	▼ Constant			
7	<Hinzufügen>			



Totally Integrated Automation Portal					
DoorInterlockingUL508A [FB1]					
DoorInterlockingUL508A Eigenschaften					
Allgemein					
Name	DoorInterlockingUL508A	Nummer	1	Typ	FB
Nummerierung	Automatisch				
Information					
Titel		Autor		Kommentar	
Version	0.1	Anwenderdefinierte ID			
Name	Datentyp	Defaultwert	Remanenz	Erreichbar aus HMI/OPC UA	Schreibbar aus HMI/OPC UA
▼ Input					
i1DoorMagnetEnergized	Bool	false	Nicht remanent	True	False
i2DoorClosed	Bool	false	Nicht remanent	True	False
i3StartDefeating	Bool	false	Nicht remanent	True	False
i4MainSwitchOn	Bool	false	Nicht remanent	True	False
i5MainSwitchtripped	Bool	false	Nicht remanent	True	False
DefeatingTime	Time	T#10s	Nicht remanent	True	True
▼ Output					
q1IndicatorLightDoorClosedInterlockingActive	Bool	false	Nicht remanent	True	False
q2IndicatorLightDefeatingActive	Bool	false	Nicht remanent	True	False
q3UndervoltageRelease	Bool	false	Nicht remanent	True	False
q4MagneticInterlockingActive	Bool	false	Nicht remanent	True	False
q5IndicatorLightMainSwitchOn	Bool	false	Nicht remanent	True	False
InOut					
▼ Static					
▼ statTimerdefeatingtime	IEC_TIMER		Nicht remanent	True	False
PT	Time	T#0ms	Nicht remanent	True	False
ET	Time	T#0ms	Nicht remanent	True	False
IN	Bool	false	Nicht remanent	True	False
Q	Bool	false	Nicht remanent	True	False
▼ statTimerChangeoverTime-Door1	IEC_TIMER		Nicht remanent	True	False
PT	Time	T#0ms	Nicht remanent	True	False
ET	Time	T#0ms	Nicht remanent	True	False
IN	Bool	false	Nicht remanent	True	False
Q	Bool	false	Nicht remanent	True	False
▼ statTimerChangeoverTime-Door2	IEC_TIMER		Nicht remanent	True	False
PT	Time	T#0ms	Nicht remanent	True	False
ET	Time	T#0ms	Nicht remanent	True	False
IN	Bool	false	Nicht remanent	True	False
Q	Bool	false	Nicht remanent	True	False
statRSFlipFlopUndervoltageRelease	Bool	false	Nicht remanent	True	False
▼ Temp					
tempUndervoltageReleaseBridgeover	Bool				
tempdefeatingSignalDuration	Bool				
▼ Constant					
CHANGEOVER_TIME_DOORS	Time	T#1000ms			

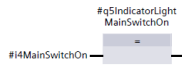
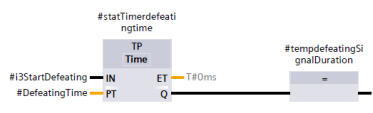
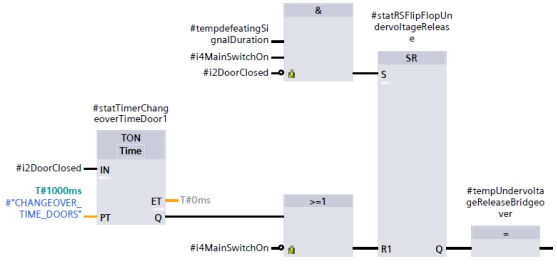
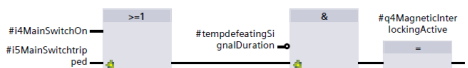
Totally Integrated Automation Portal		
Netzwerk 1: Indicator light "Doors closed and interlocking active" true = all doors closed and interlocking is active false = doors open or interlocking is deactivated		
		
Netzwerk 2: Indicator light "Main switch ON"		
		
Netzwerk 3: Start defeating time and output as an extended pulse A temporary extended signal for unlocking the magnets is generated edge-triggered by a key-operated pushbutton. The defeating time is 10s by default and can be defined externally through a block input.		
		
Netzwerk 4: Signal generation to bypass the undervoltage release Background functional sequence: When the main switch is opened, all doors are unlocked and can be opened. However, if the main switch is closed again while one or more doors of the electrical interlocking are still open, the main switch is tripped by the undervoltage release and it drops into the "tripped" position. If this must be prevented (for maintenance reasons), defeating must be started before the main switch is closed again while one or more doors are open.		
		
Netzwerk 5: Control of magnetic tumbler (locking device) Background functional sequence Operator control of "electrical" defeating function: a) Using a key-operated pushbutton (-S15), a 10-second unlocking time of the magnets of the position switches is enabled here via block B02 (interval relay, edge-triggered). b) If no door is opened during this time; (i.e. the actuators of the position switches remain locked), the magnets are energized again after 10 seconds and the doors remain locked. c) If one or more doors are opened during this time, all magnets of the position switches are energized again after 10 seconds and the unopened doors remain locked. d) If an open door is closed again, the actuator is automatically locked again with the magnet, which has already been energized.		
		
Netzwerk 6: Indicator light for defeating, true = active, false = deactivated		
		
Netzwerk 7: Control of the undervoltage release Control of the undervoltage release: true = normal voltage, false = undervoltage release is tripped Background functional sequence: When the main switch is opened, all doors are unlocked and can be opened. However, if the main switch is closed again while one or more doors of the electrical interlocking are still open, the main switch is tripped by the undervoltage release and it drops into the "tripped" position.		

Diagram illustrating the logic for defeating the main switch when one or more doors are open:

```

graph LR
    subgraph "Totally Integrated Automation Portal"
        direction TB
        T1["T#1000ms"]
        C1["#CHANGEOVER_TIME_DOORS"]
    end

    subgraph "TOF Time"
        direction TB
        IN["IN"]
        ET["ET"]
        Q["Q"]
    end

    subgraph "Logic"
        direction TB
        L1[">=1"]
        L2["#q3Undervoltage Release"]
    end

    C1 --> IN
    T1 --> IN
    IN --> ET
    ET -- "T#0ms" --> Q
    Q --> L1
    L1 --> L2
    L2 --> Output["#tempdefeatingSignalDuration"]
  
```

The diagram shows a sequence of events: a door closure signal (#2DoorClosed) and a time delay (T#1000ms) trigger the start of a TOF (Time Over Follow) block. The TOF block's output (Q) is connected to a logic block that checks if the signal is greater than or equal to 1. If true, it triggers the #q3Undervoltage Release, which then sets the #tempdefeatingSignalDuration.

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