Checklist Controller (PLC)

Scope

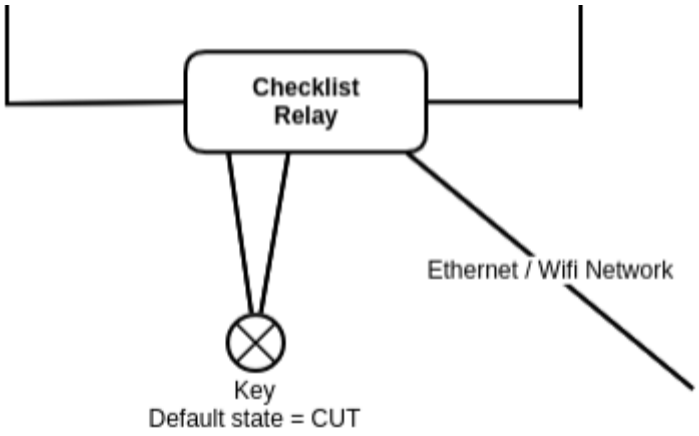
DC Plus Engineering is approached by Mesh and Bar to provide Relay element of their “Locked out digital checklist” solution.

The Relay element will be implemented as a stand-alone PLC referred as Checklist Controller PLC in this document. It is separate from any existing machine network, receiving its command from external PC/Tablet via single direct Ethernet connection.

Functional Requirement

Initial Requirement

In reference to (2020-09-16 - EU - Mesh & Bar - Locked out digital checklist) documentation in Appendix-C:



The relay in the above diagram is a PLC which provides an IP integration into the safety system which can be isolated from the existing factory network / wifi network by having the device that connects to this PLC have a back to back connection via ethernet cable. The device will be programmed to start in an open (broken) state, effectively triggering the safety relay and immobilising the machine (through the current safety mechanisms of the machine).

Once the check-list is completed, a signal will be sent to the PLC to close (un-break) the circuit. This will enable the machine to operate in its desired / normal

state. As the PLC will start with an open state, a power loss to the manufacturing machine will require an operator to perform the safety checks for that machine for the day. A configurable parameter for how long a check is valid for (in hours) will be part of the software design to ensure that a machine which is powered on for multiple days, still requires a safety check to be performed.

The inclusion of a key into the solution allows for any period where there are IT issues with the tablet communicating to the PLC. During these times, the check-list will revert to a paper based system. The key operation will be logged upon reinstatement of the Tablet communication with the Checklist PLC, and warnings will be sent that the key override is in effect.

Additional Requirement

when enabling the system (i.e. closing the circuit) the business would like 2 terminals available to be able to trigger a light & siren.

The light should operate for the first 5 seconds of operation

The siren should operate for 3 seconds before opening the circuit.

Manufacturer Approach

The solution is not intended to be part of Machine Safety Circuit, but instead an added pre-condition of Machine Controller operational.

Checklist functionality and warning indicators are intended to benefit operational awareness of machine environment.

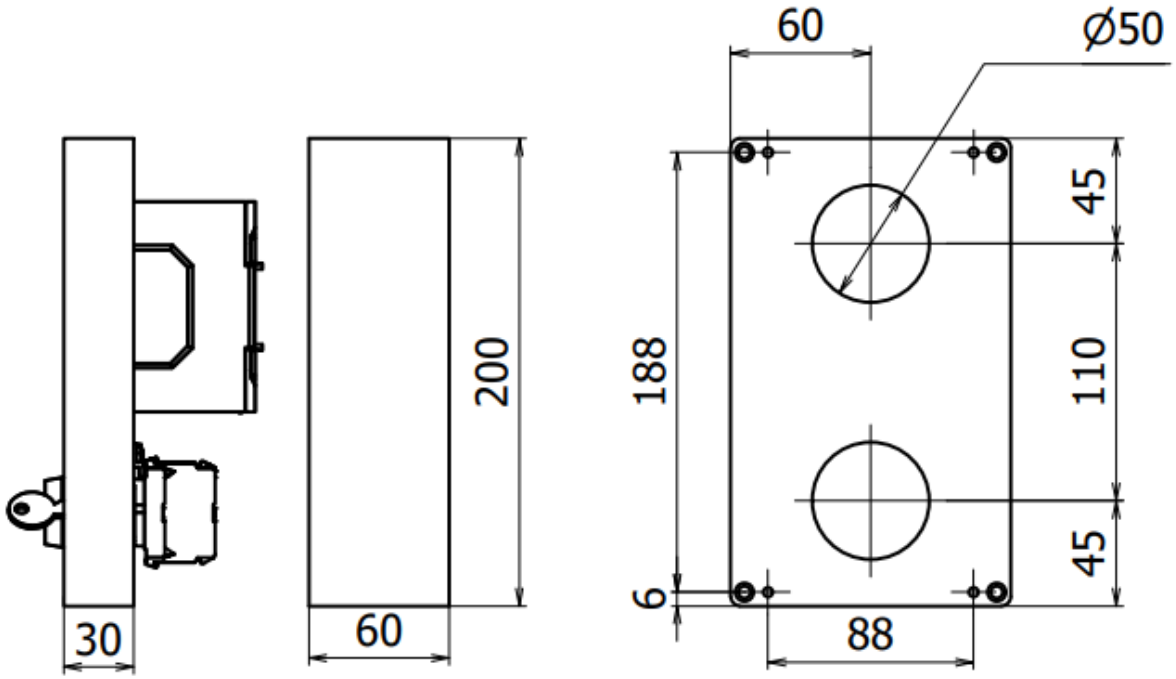
The failure and/or malfunction of this solution shall not endanger the safety of persons; appropriate installation shall be conducted, verified and validated by competent technical personnel.

Implementation

Hardware and Mounting

Checklist Controller PLC is contained in a 120x200x90mm ABS enclosure intended for mounting outside of existing machine operator panel.

Enclosure to be mounted vertically through two mounting holes of 51mm diameter at 110mm pitch. Refer to below image for dimension.



Electrical Connection

Refer to Appendix-A for Checklist Controller (PLC) internal schematic. Below listed connection to be integrated to current machine controller.

24VDC	Supply DC 24V
0VDC	Common DC reference
SAF	Ready signal from existing safety system confirming Safety requirements is satisfied
ENA1	First enable relay, common side
ENA2	First enable relay, contact side
ENB1	Second (optional) enable relay, common side
ENB2	Second (optional) enable relay, contact side
LIGHT	Indicator signal for Light, 24VDC
STROBE	Indicator signal for Strobe, 24VDC

Recommendation for Enable Relay connection

Connect Enable relay in series to existing machine connection with selection based on below preference. Acquire advise from competent technical personnel in making this selection.

1. Input to Machine Controller PLC indicating Safety Circuit is established, or
2. Input to Machine Controller PLC which Trigger Fault / Alarm, or
3. Input to Machine Controller PLC from START RUN button, or
4. Output of Machine Controller PLC which trigger a Main Drive, electric or hydraulic

Refer to table below for Relay output contact load rating. Loads outside specification will require external interface relay for operation.

Output Specifications for Relay Outputs

CP2E-□□□DR-□

Item			Specification
Maximum switching capacity			2 A 250 VAC (cosϕ= 1) 2 A 24 VDC (4 A/common)
Minimum switching capacity			10 mA 5 VDC
Service life of relay	Electrical	Resistive load	200,000 operations (24 VDC)
		Inductive load	70,000 operations (250 VAC, cosϕ = 0.4)
	Mechanical		20,000,000 operations
ON response time			15 ms max.
OFF response time			15 ms max.

Software Behavior

Functions implemented by Checklist Controller PLC are explained in this section. Refer to Appendix-B for PLC software code export.

Receive “close” command

The “close” signal can be triggered over FINS, which
To prevent false pulse trigger, signal need to be maintained for minimum 500ms to trigger an Enable. The memory address will be cleared after 1-sec requiring new signal for every event.

“close” signal, memory address, W0.00

Enable machine to operate

Conditional to SAF input, “close” signal will set Enable latch.
Output STROBE will operate for 3-sec, when it ends Enable Outputs ENA and ENB will latch.
Output LIGHT will operate for first 5-sec of Enable Outputs ENA and ENB.

SAF input address, 0.00
ENA (1,2) output address, 100.00

ENB (1,2) output address, 100.02
LIGHT output address, 100.04
STROBE output address, 100.05

Check valid only until configured period

Enable latch will reset after set minutes of operation to ensure a machine which is powered on for multiple days, still requires a safety check to be performed.

Max Valid minutes memory address, (UINT) D0

Bypass key to enable

Input KEY can set Enable latch, requiring signal to stay HIGH for minimum 1-sec.
Input KEY need to be LOW while output STROBE is HIGH, otherwise bypass key input is invalid, this prevents the key left indefinitely in the controller switch.

KEY input address, 0.07

Key operation log

Upon successful Key bypass, the event is logged in Checklist Controller PLC memory.
Upon reinstatement of Tablet communication, logged data can be assessed with reference to PLC Clock Date and Time value.

Log data, First memory address, D100-D10099
Log data, Most recent memory address, D100
Log data size per entry, 10-words
Maximum Log data, 1000-entry

Log data word n+0 to n+2, (example, D100 D101 D102 for most recent entry) is according to PLC CLOCK memory arrangement below.

Name	Address	Function
Clock data	A351 to A354	The seconds, minutes, hour, day of month, month, year, and day of week are stored each cycle.
	A351.00 to A351.07	Seconds: 00 to 59 (BCD)
	A351.08 to A351.15	Minutes: 00 to 59 (BCD)
	A352.00 to A352.07	Hour: 00 to 23 (BCD)
	A352.08 to A352.15	Day of the month: 01 to 31 (BCD)
	A353.00 to A353.07	Month: 01 to 12 (BCD)
	A353.08 to A353.15	Year: 00 to 99 (BCD)

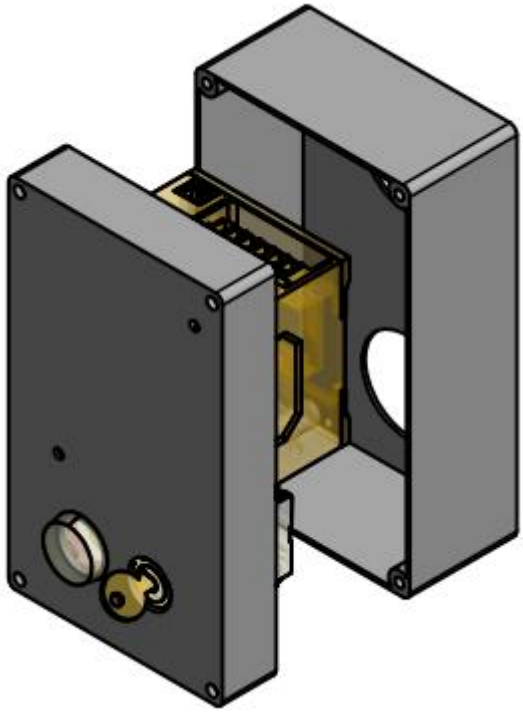
Log data word n+3, (example, D103 for most recent entry) provide register of event type.

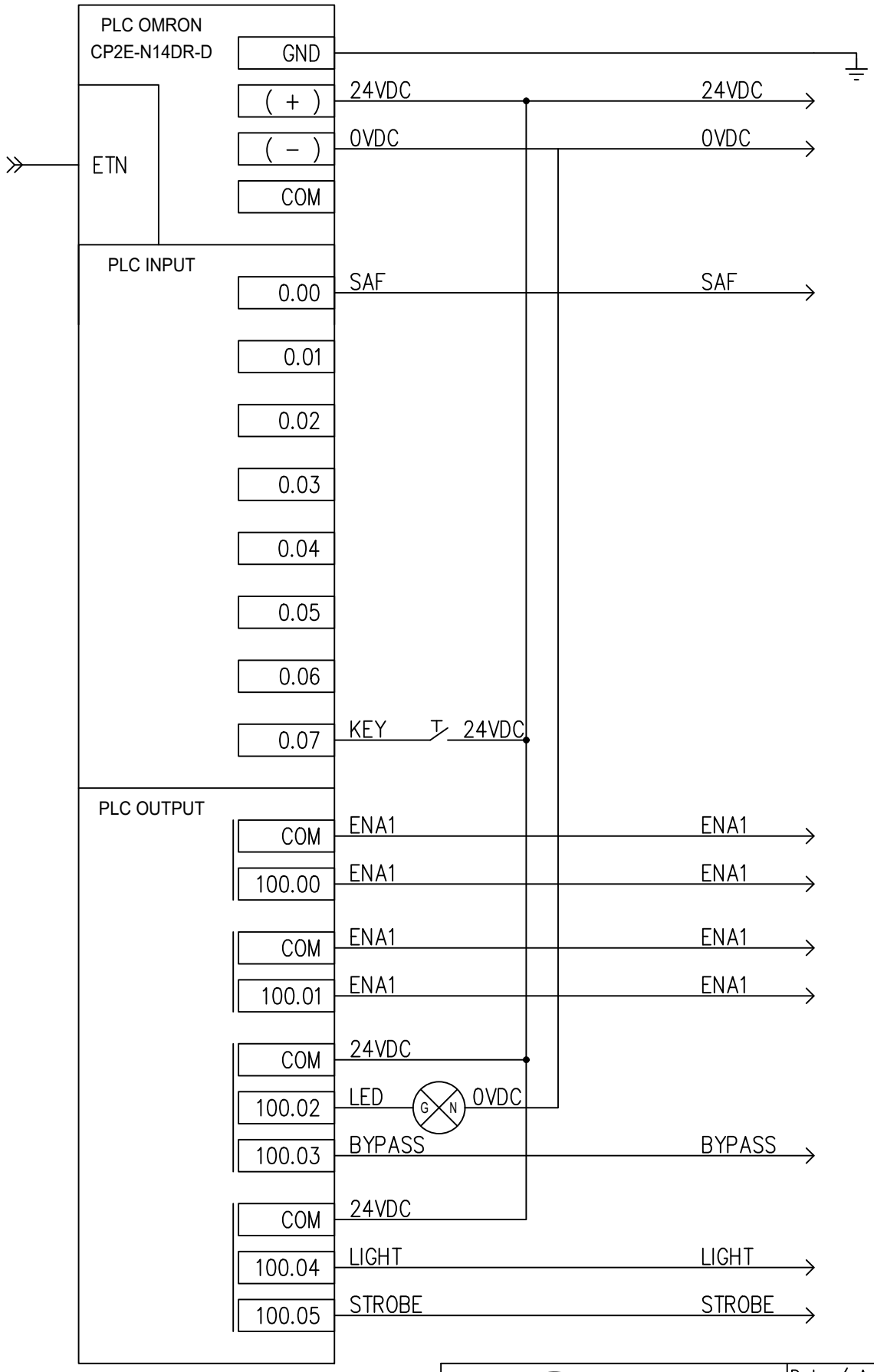
Bypass Request accepted, code #1
Bypass Request rejected, code #2

Log data words n+4 to n+9 have NULL value reserved.

APPENDIX-A

Checklist Controller PLC internal schematic.





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04MAY2021

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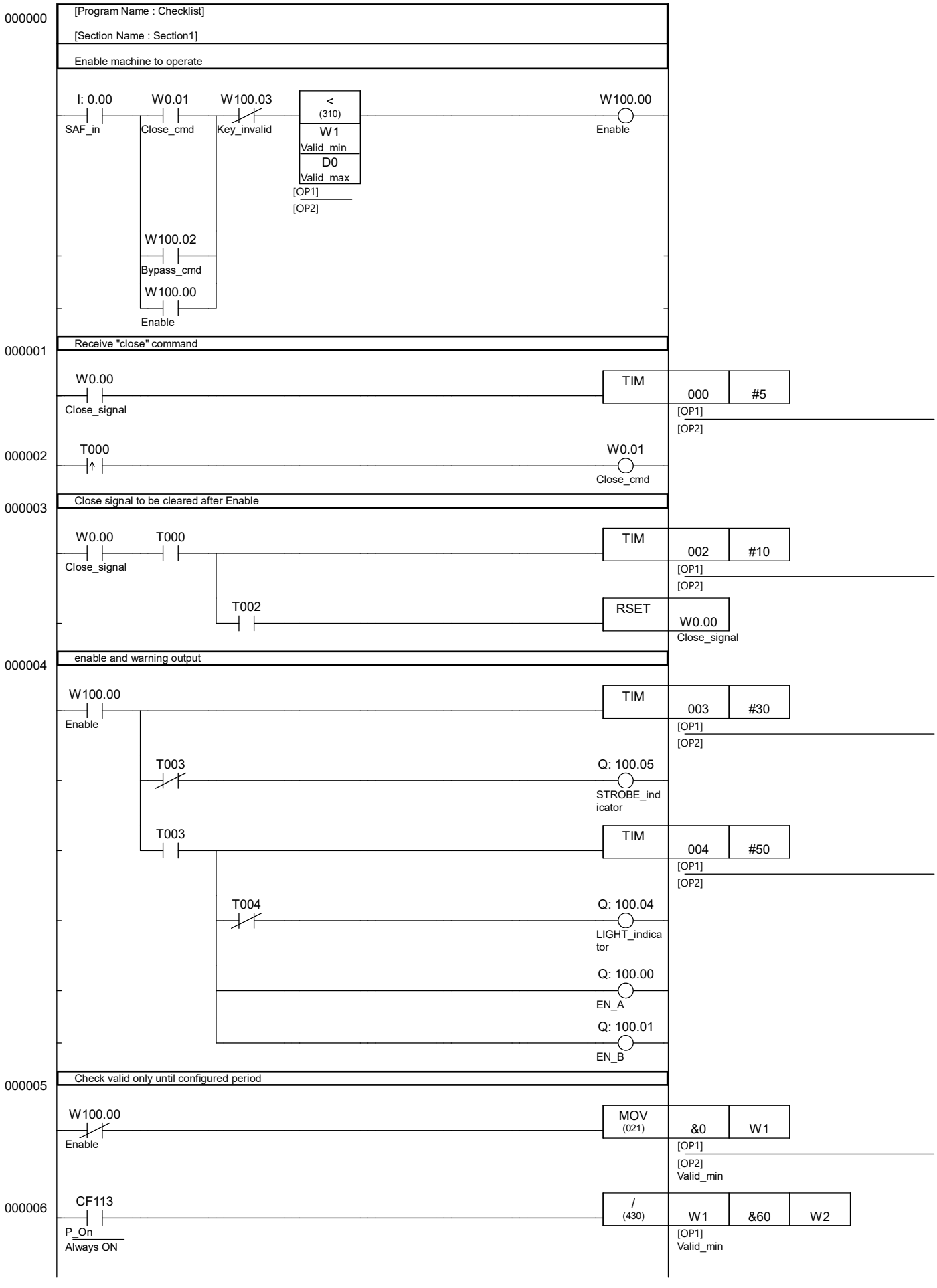
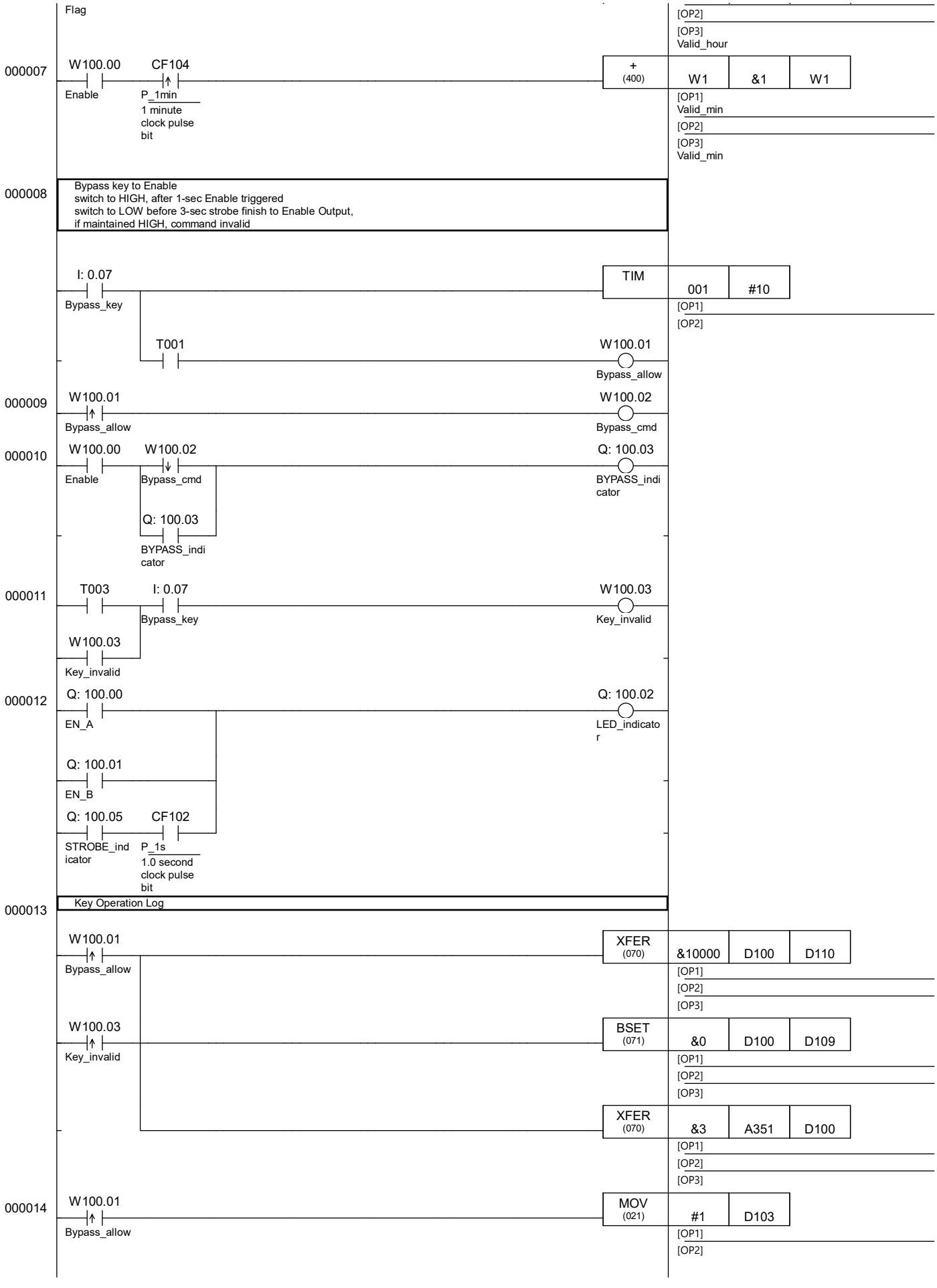
Drawing / Job Number
Checklist PLC S21134

APPENDIX-B

Checklist Controller PLC Software code export


000000
[Program Name : Checklist]
[Section Name : Section1]
Enable machine to operate
I: 0.00
SAF_in
W0.01
Close_cmd
W100.03
Key_invalid
<
(310)
W1
Valid_min
D0
Valid_max
[OP1]
[OP2]
W100.00
Enable
W100.02
Bypass_cmd
W100.00
Enable
000001
Receive "close" command
W0.00
Close_signal
TIM
000
#5
[OP1]
[OP2]
000002
T000
W0.01
Close_cmd
000003
Close signal to be cleared after Enable
W0.00
Close_signal
T000
TIM
002
#10
[OP1]
[OP2]
T002
RSET
W0.00
Close_signal
000004
enable and warning output
W100.00
Enable
TIM
003
#30
[OP1]
[OP2]
T003
Q: 100.05
STROBE_ind
icator
T003
TIM
004
#50
[OP1]
[OP2]
T004
Q: 100.04
LIGHT_indica
tor
Q: 100.00
EN_A
Q: 100.01
EN_B
000005
Check valid only until configured period
W100.00
Enable
MOV
(021)
&0
W1
[OP1]
[OP2]
Valid_min
000006
CF113
P_On
Always ON
/
(430)
W1
&60
W2
[OP1]
Valid_min


Flag
[OP2]
[OP3]
Valid_hour
000007
W100.00
Enable
CF104
P_1min
1 minute
clock pulse
bit
+
(400)
W1
&1
W1
[OP1]
Valid_min
[OP2]
[OP3]
Valid_min
000008
Bypass key to Enable
switch to HIGH, after 1-sec Enable triggered
switch to LOW before 3-sec strobe finish to Enable Output,
if maintained HIGH, command invalid
I: 0.07
Bypass_key
TIM
001
#10
[OP1]
[OP2]
T001
W100.01
Bypass_allow
000009
W100.01
Bypass_allow
W100.02
Bypass_cmd
000010
W100.00
Enable
W100.02
Bypass_cmd
Q: 100.03
BYPASS_indi
cator
Q: 100.03
BYPASS_indi
cator
000011
T003
I: 0.07
Bypass_key
W100.03
Key_invalid
W100.03
Key_invalid
000012
Q: 100.00
EN_A
Q: 100.02
LED_indicato
r
Q: 100.01
EN_B
Q: 100.05
STROBE_ind
icator
CF102
P_1s
1.0 second
clock pulse
bit
000013
Key Operation Log
W100.01
Bypass_allow
XFER
(070)
&10000
D100
D110
[OP1]
[OP2]
[OP3]
W100.03
Key_invalid
BSET
(071)
&0
D100
D109
[OP1]
[OP2]
[OP3]
XFER
(070)
&3
A351
D100
[OP1]
[OP2]
[OP3]
000014
W100.01
Bypass_allow
MOV
(021)
#1
D103
[OP1]
[OP2]


000015
W100.03
Key_invalid
MOV
(021)
#2
D103
[OP1]
[OP2]