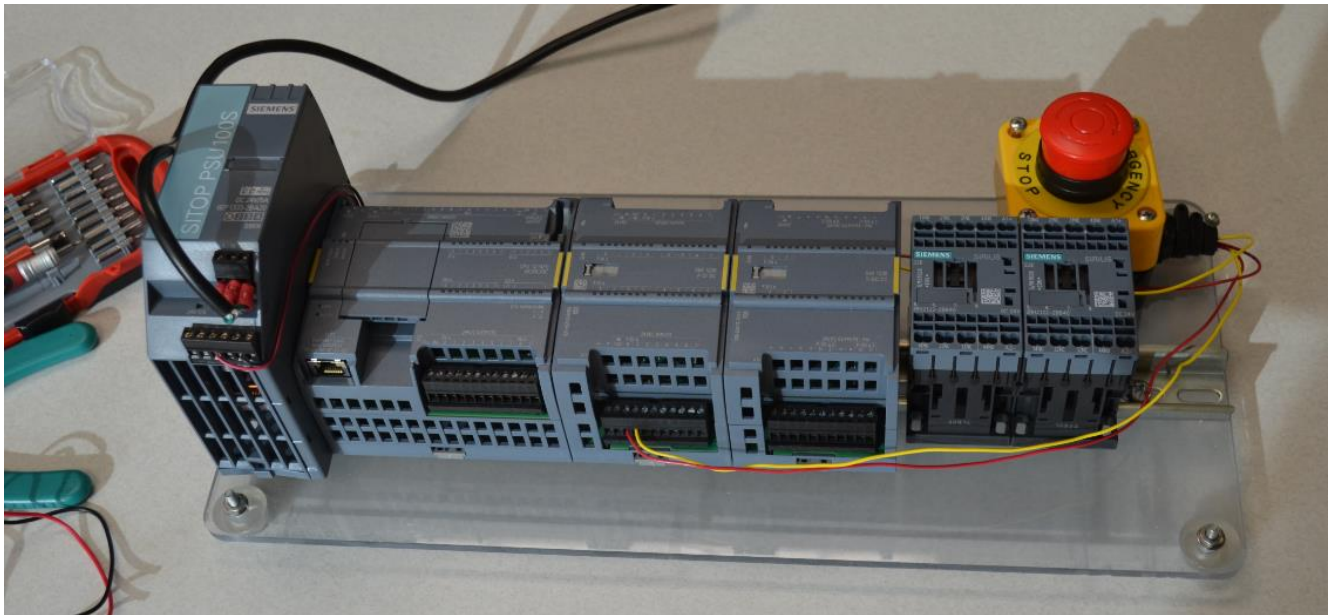


Chapter 26 Safety Lab

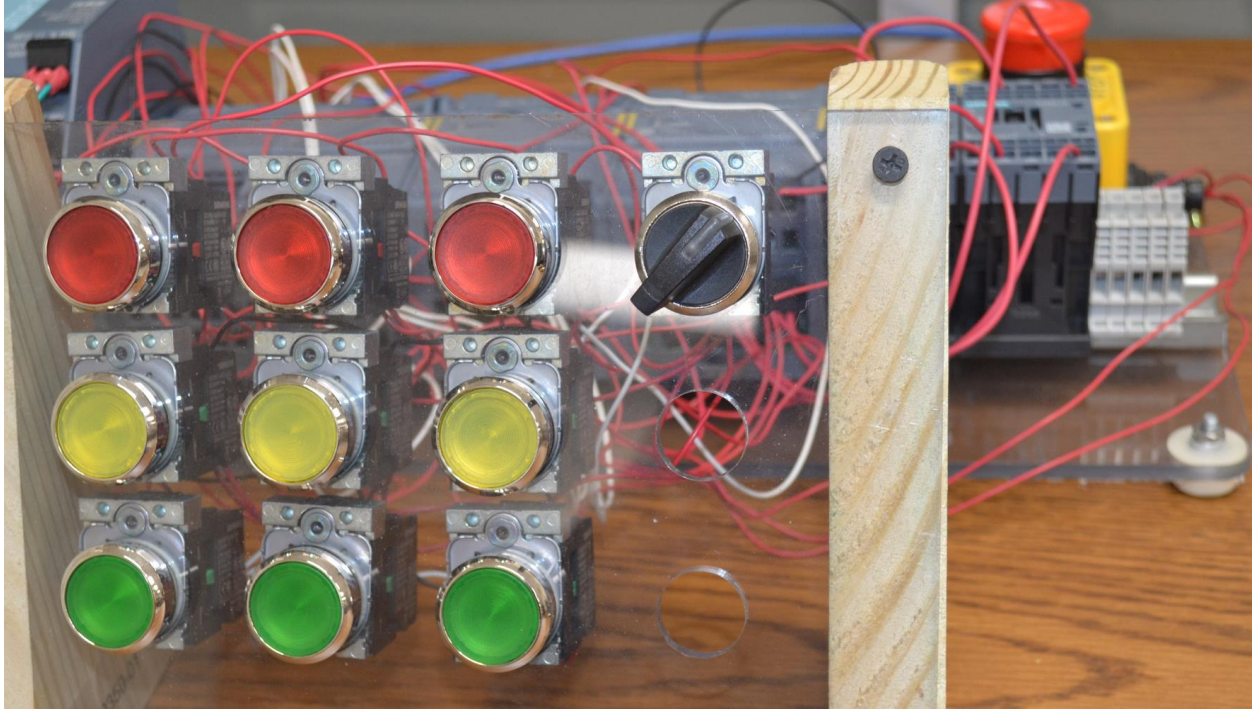
Our Equipment includes:

Siemens CPU 1214FC DC/DC/DC PLC
Siemens SM 1226 F-DI DC Input Module
Siemens SM 1226 F-DQ DC Output Module
Two Siemens Sirius 3RH2122-2BB40 Relays
An Emergency Stop Station

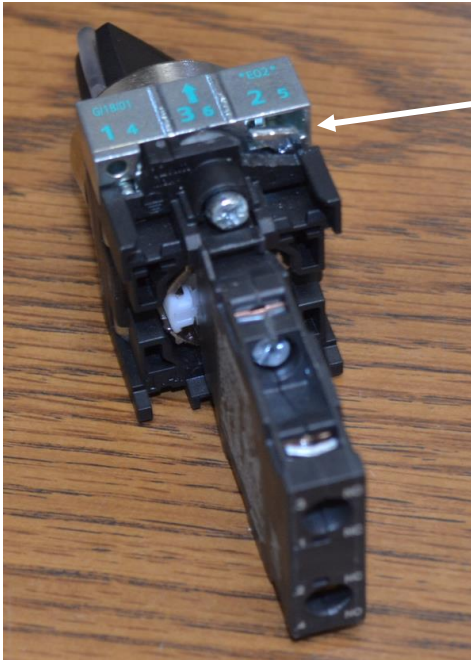
The layout of our system is pictured below. On the left is a power supply, then the CPU followed by the Input Module, Output Module and two Relays. Upper right is an Emergency Stop station. In this lab, it is referred to as the Local Estop.



Since several non-safety Inputs and Outputs are used in the lab, we will use the pushbutton station from the lab, shown on the next page. You may have a Pushbutton station without any selector switch.

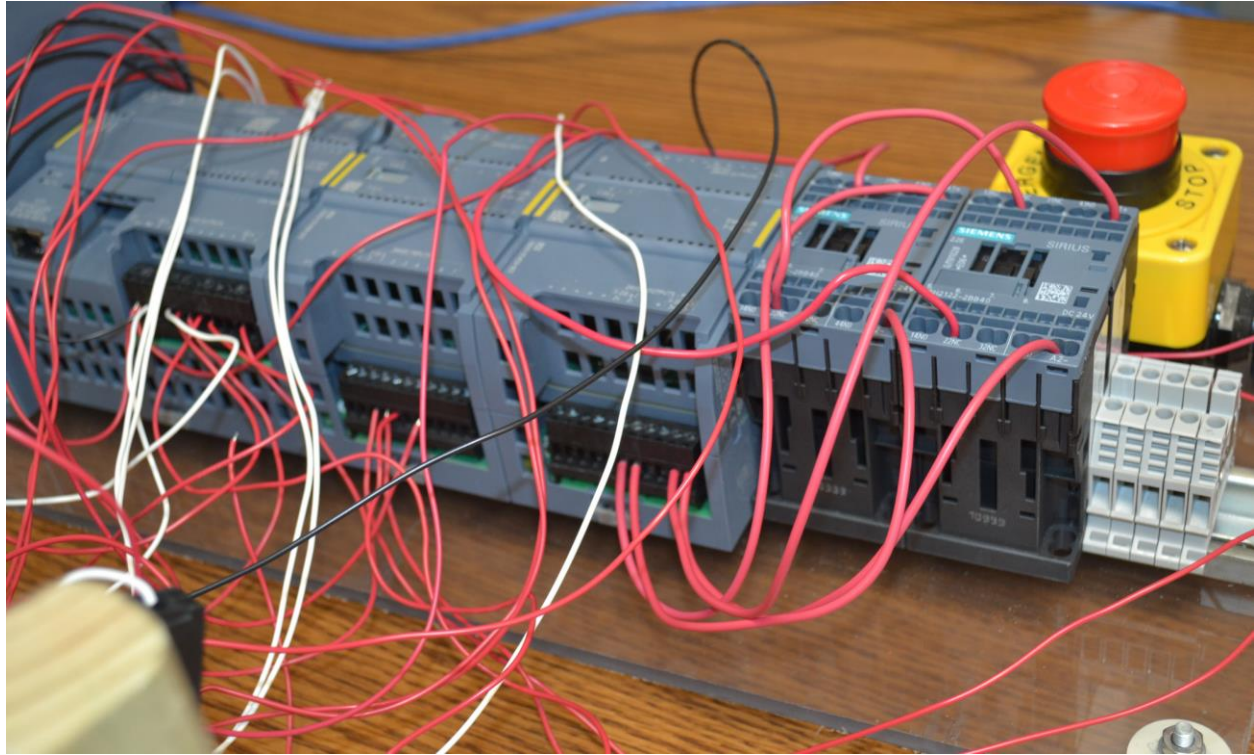


Also, wiring of the two relays requires a larger gauge wire. In the lab are some spools of 16 AWG solid copper wire. Use this wire for the relays. In order to connect the wire in these relays, use a screwdriver in the slot next to where the wire is inserted. Push the connection to open the slot, insert the wire and stop pushing the connection. Test the wire. It should be snug in the connector.



In order to change or move Siemens buttons, simply move the lever to the **left** as shown. It may not move easily so first you may need to loosen the screw and then move the lever.

Also, wiring of the two relays requires a larger gauge wire. In the lab are some spools of 16 AWG solid copper wire. Use this wire for the relays. In order to connect the wire in these relays, use a screwdriver in the slot next to where the wire is inserted. Push the connection to open the slot, insert the wire and stop pushing the connection. Test the wire. It should be snug in the connector. The heavier wire can be easily seen in the picture below:



The push buttons pictured in the following figure are referred to later as the “Pushbutton Station” in the wiring diagram. You may have only the push buttons and not the selector switches. You will need one selector switch to complete the assignment.



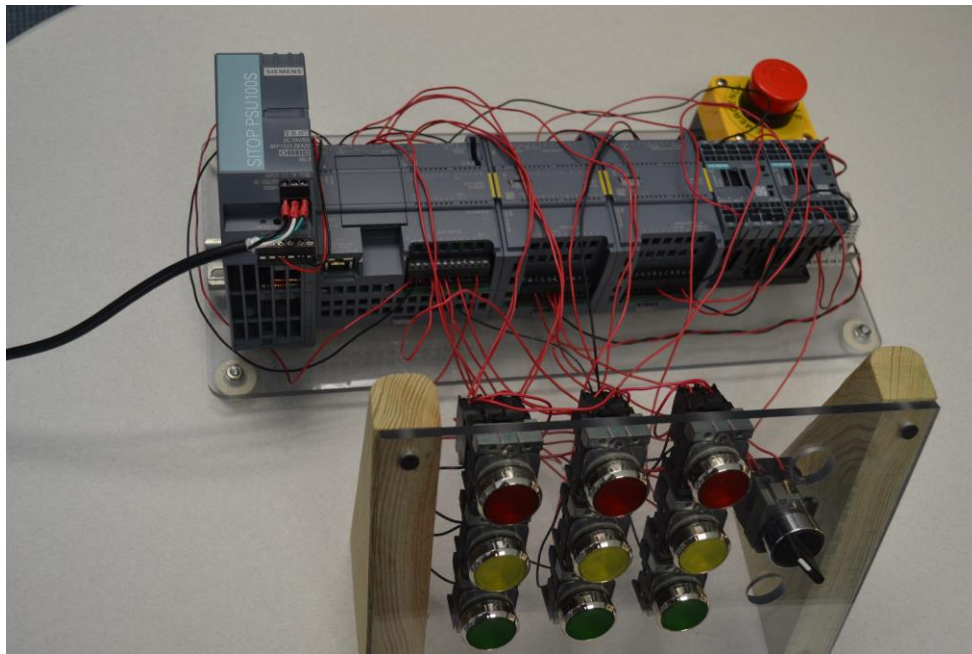
The back of the pushbutton panel is shown below:

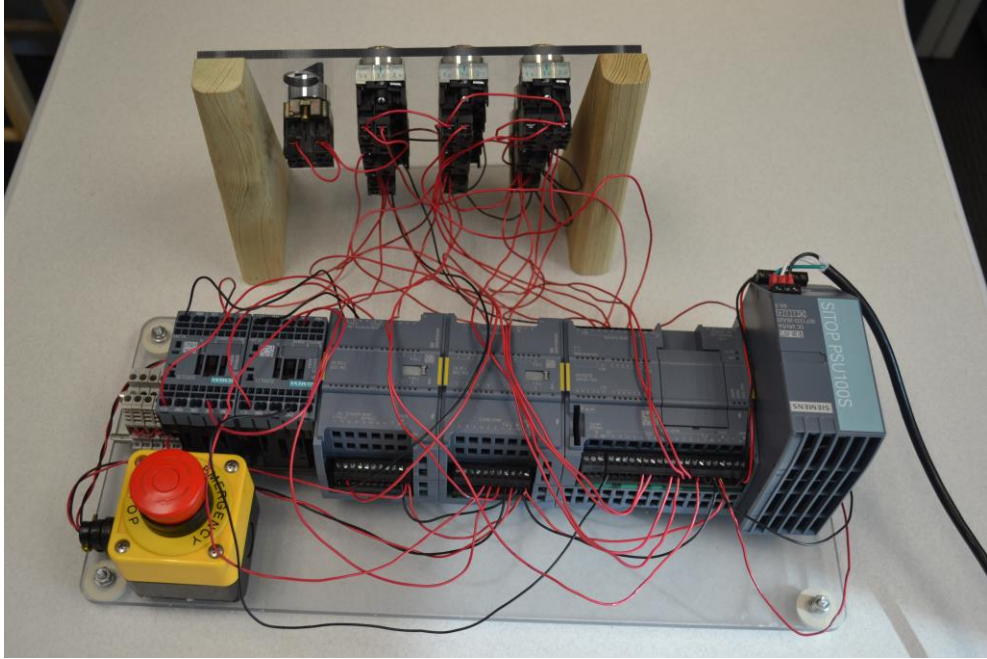


The original solution to this lab was done by Austin Rhoads, EET Student – April 2021:

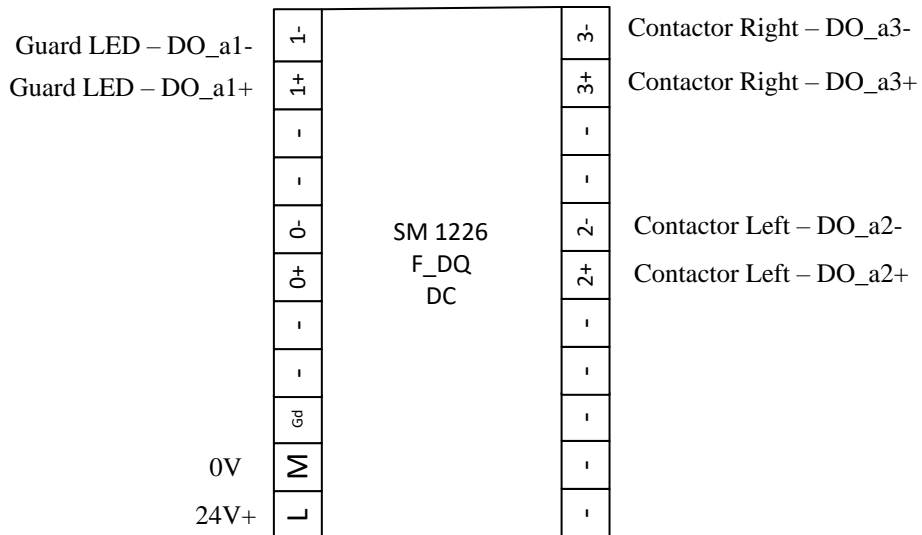
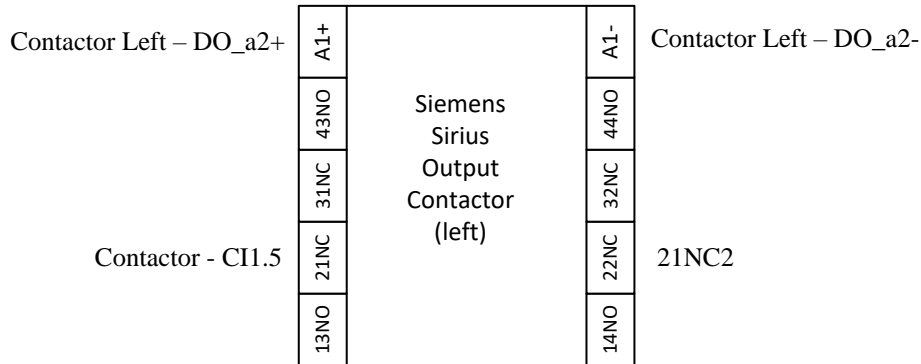
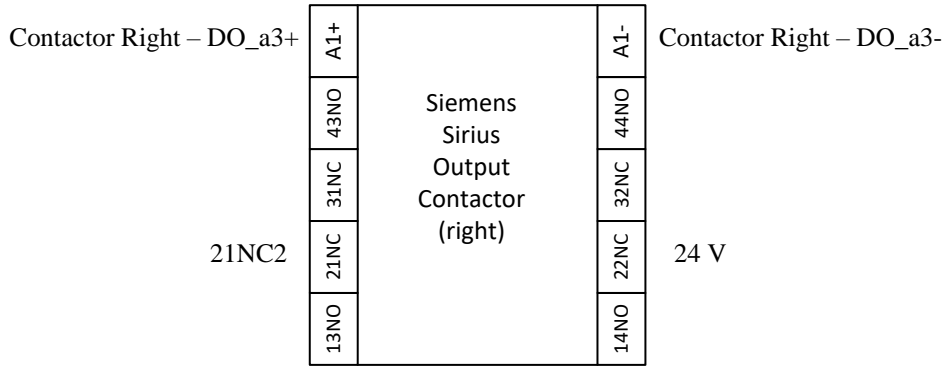
Download the program ‘Siemens Safety Advanced Program’ from the hybridplc.org website.

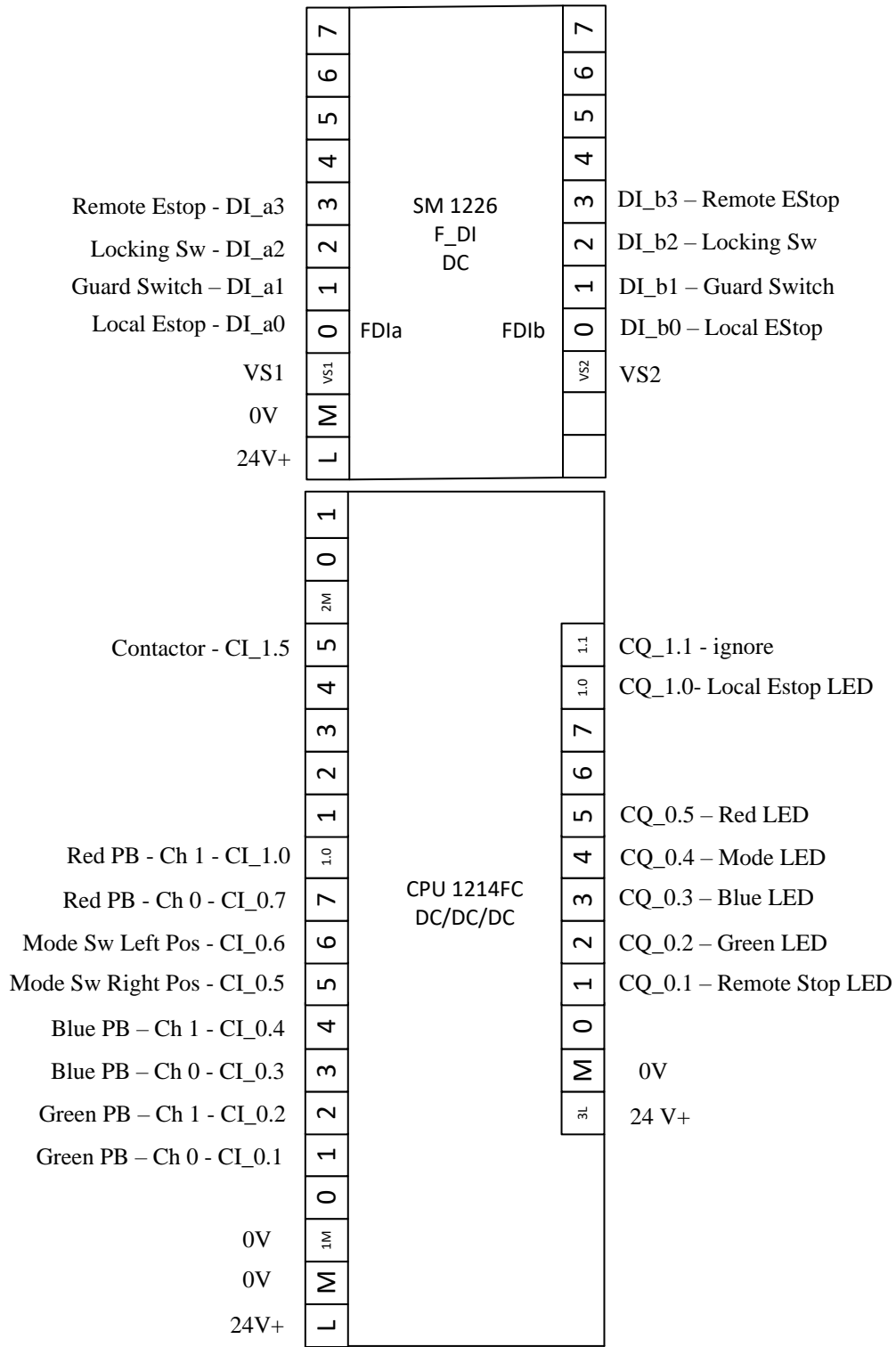
Your lab will resemble somewhat the following figure when complete:







The following three figures show the wiring diagram of the components in the lab. Follow the diagrams and complete the wiring to each terminal as shown. Then download the program to the PLC and begin the debugging process.





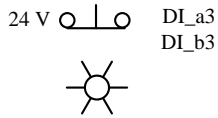
Local Estop
Station

VS1  Local Estop DI_a_0

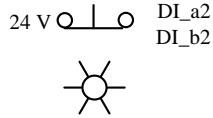
VS2  Local Estop DI_b_0

PushButton
Station

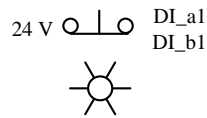
Remote EStop



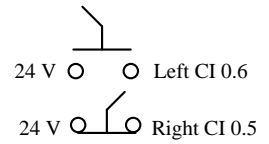
Locking Sw



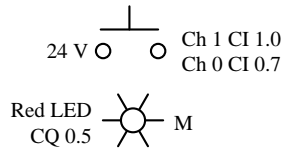
Guard Sw



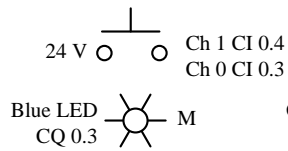
Mode Sw



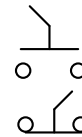
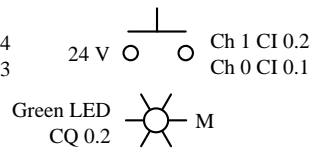
Red PB




Blue PB




Green PB




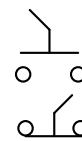
Local EStop  CQ 1.0 M



Remote EStop  CQ 0.1 M

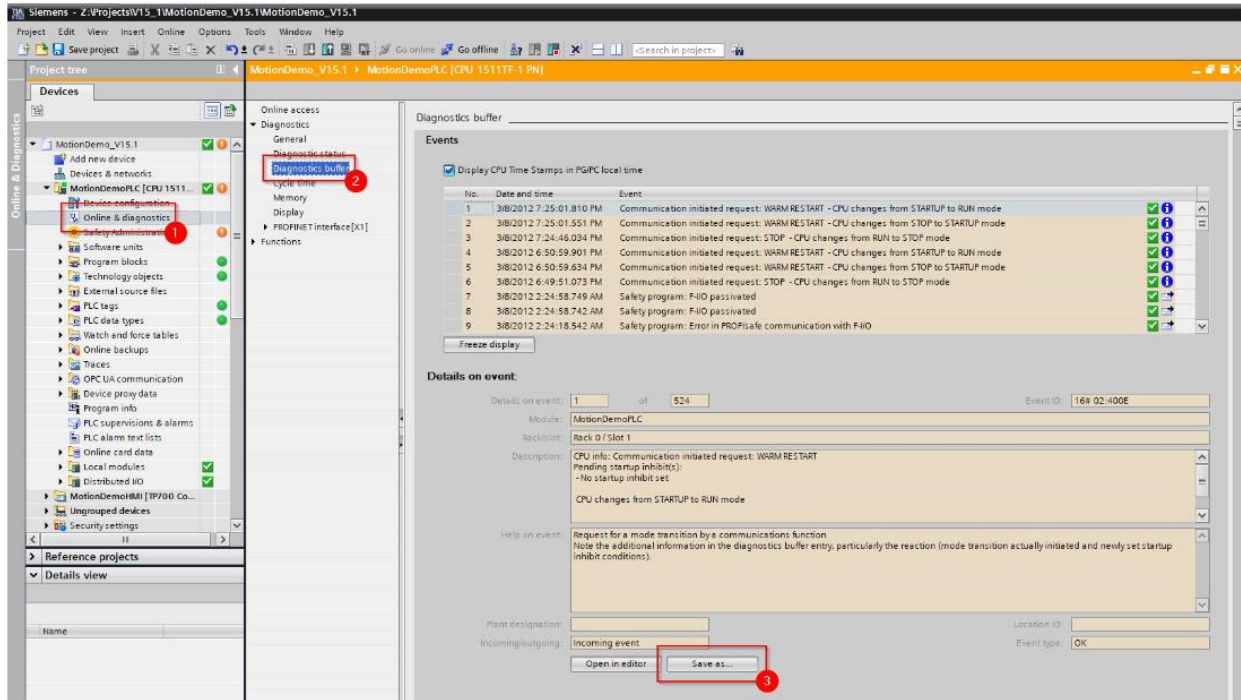


Mode LED  CQ 0.4 M



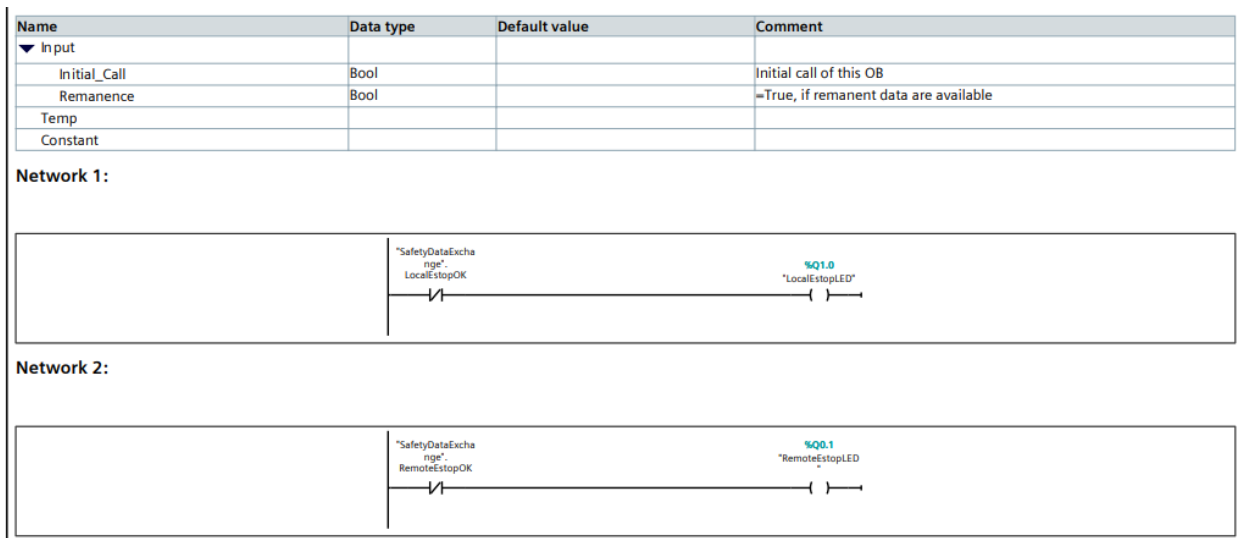
Note that the referenced Red PB, Blue PB and Green PB are not actually these colors but are labelled as such in the program. The button colors for all three are yellow.

The following is a troubleshooting page to be used if there is an error in the wiring or configuration of the program:

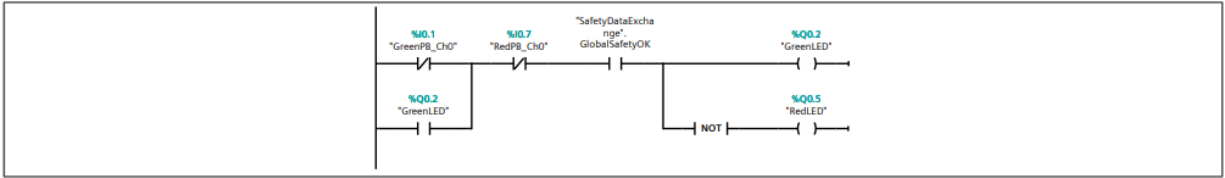


The figures that follow are the program listing for the programs as well as the configuration pages of the various OB's and FB's:

First, OB1:



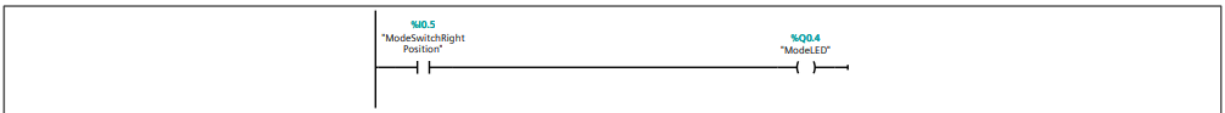
Network 3:



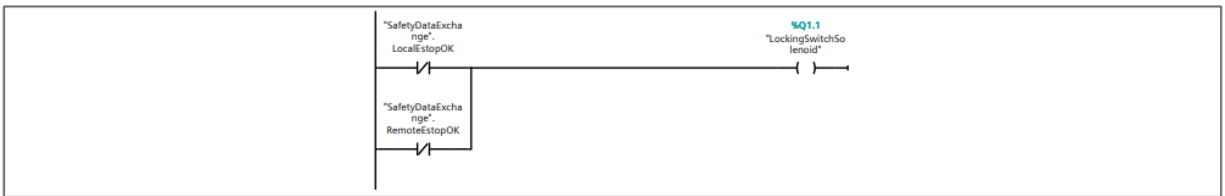
Network 4:



Network 5:



Network 6:

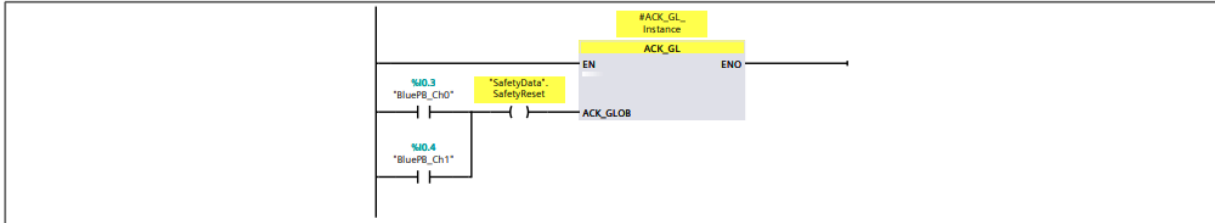


▼ LocalEstopStatus	ESTOP1				True	True	True	True		
▼ Input										
E_STOP	Bool	false	Non-retain	True	True	True	False			Emergency STOP
ACK_NEC	Bool	true	Non-retain	True	True	True	False			1=Acknowledgment necessary
ACK	Bool	false	Non-retain	True	True	True	False			1=Acknowledgment
TIME_DEL	Time	0	Non-retain	True	True	True	False			Time delay
▼ Output										
Q	Bool	false	Non-retain	True	True	True	False			1=Enable
Q_DELAY	Bool	false	Non-retain	True	True	True	False			Enable is OFF delayed
ACK_REQ	Bool	false	Non-retain	True	True	True	False			1=acknowledgment request
DIAG	Byte	B#16#00	Non-retain	True	True	True	False			Service information
InOut										
Static										
▼ GuardStatus	ESTOP1				True	True	True	True		
▼ Input										
E_STOP	Bool	false	Non-retain	True	True	True	False			Emergency STOP
ACK_NEC	Bool	true	Non-retain	True	True	True	False			1=Acknowledgment necessary
ACK	Bool	false	Non-retain	True	True	True	False			1=Acknowledgment
TIME_DEL	Time	0	Non-retain	True	True	True	False			Time delay
▼ Output										
Q	Bool	false	Non-retain	True	True	True	False			1=Enable
Q_DELAY	Bool	false	Non-retain	True	True	True	False			Enable is OFF delayed
ACK_REQ	Bool	false	Non-retain	True	True	True	False			1=acknowledgment request
DIAG	Byte	B#16#00	Non-retain	True	True	True	False			Service information
InOut										
Static										
▼ RemoteEstopStatus	ESTOP1				True	True	True	True		
▼ Input										
E_STOP	Bool	false	Non-retain	True	True	True	False			Emergency STOP
ACK_NEC	Bool	true	Non-retain	True	True	True	False			1=Acknowledgment necessary
ACK	Bool	false	Non-retain	True	True	True	False			1=Acknowledgment
TIME_DEL	Time	0	Non-retain	True	True	True	False			Time delay
▼ Output										
Q	Bool	false	Non-retain	True	True	True	False			1=Enable
Q_DELAY	Bool	false	Non-retain	True	True	True	False			Enable is OFF delayed
ACK_REQ	Bool	false	Non-retain	True	True	True	False			1=acknowledgment request
DIAG	Byte	B#16#00	Non-retain	True	True	True	False			Service information
InOut										
Static										
▼ Contactors	FDBACK				True	True	True	True		
▼ Input										
ON	Bool	false	Non-retain	True	True	True	False			1=Enable output
FEEDBACK	Bool	false	Non-retain	True	True	True	False			Feedback input

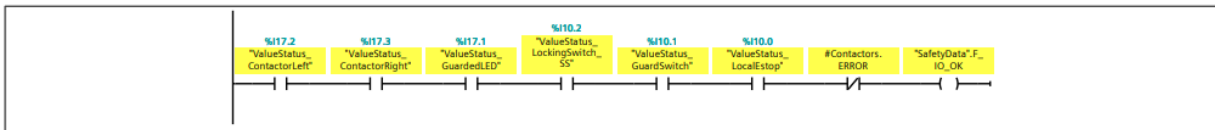
Name	Data type	Default value	Retain	Accessible from HMI/OPC UA/Web API	Writ-able from HMI/OPC UA/Web API	Visible in HMI engineering	Setpoint	Supervision	Comment
QBAD_FIO	Bool	false	Non-retain	True	True	True	False		QBAD signal of FIO/channel of output Q
ACK_NEC	Bool	true	Non-retain	True	True	True	False		1=Acknowledgment necessary
ACK	Bool	false	Non-retain	True	True	True	False		Acknowledgment
FDB_TIME	Time	T#0ms	Non-retain	True	True	True	False		Feedback time
▼ Output									
Q	Bool	false	Non-retain	True	True	True	False		Output
ERROR	Bool	false	Non-retain	True	True	True	False		Feedback error
ACK_REQ	Bool	false	Non-retain	True	True	True	False		1=acknowledgment request
DIAG	Byte	B#16#00	Non-retain	True	True	True	False		Service information
InOut									
Static									
ContactoOutput	Bool	false	Non-retain	True	True	True	False		
▼ LockingSwitch_SS_Status	ESTOP1			True	True	True	False		
▼ Input									
E_STOP	Bool	false	Non-retain	True	True	True	False		Emergency STOP
ACK_NEC	Bool	true	Non-retain	True	True	True	False		1=Acknowledgment necessary
ACK	Bool	false	Non-retain	True	True	True	False		1=Acknowledgment
TIME_DEL	Time	0	Non-retain	True	True	True	False		Time delay

▼ Output									
Q	Bool	false	Non-retain	True	True	True	False		1=Enable
Q_DELAY	Bool	false	Non-retain	True	True	True	False		Enable is OFF delayed
ACK_REQ	Bool	false	Non-retain	True	True	True	False		1=acknowledgment request
DIAG	Byte	B#16#00	Non-retain	True	True	True	False		Service information
InOut									
Static									
Temp									
Constant									

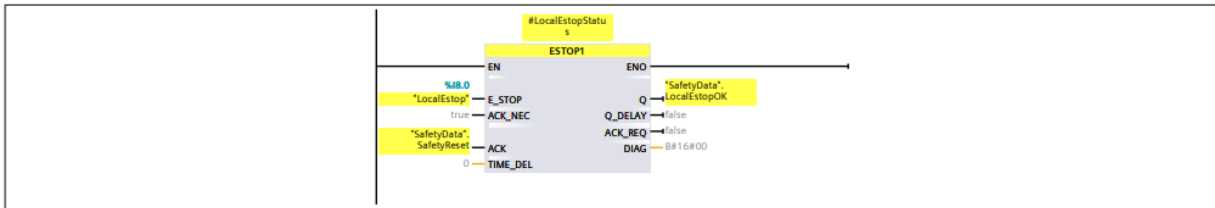
Network 1:



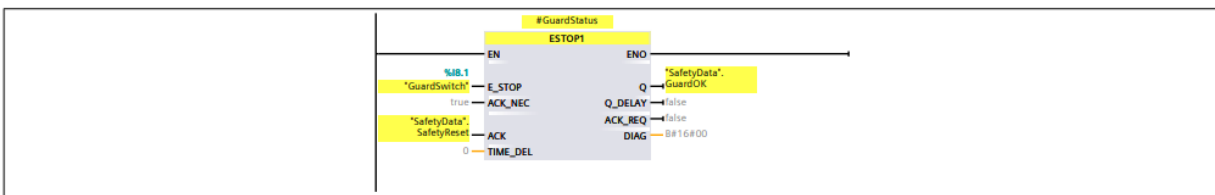
Network 2:



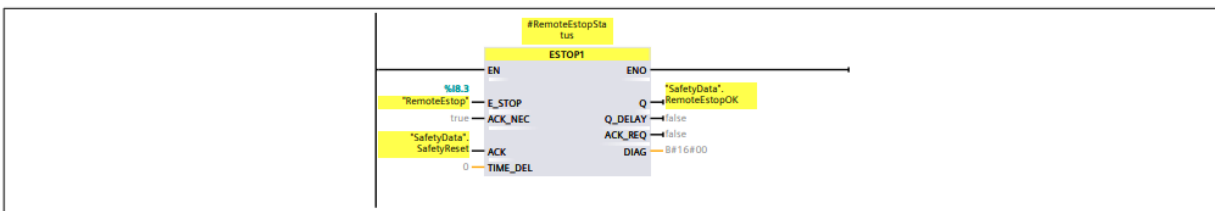
Network 3:



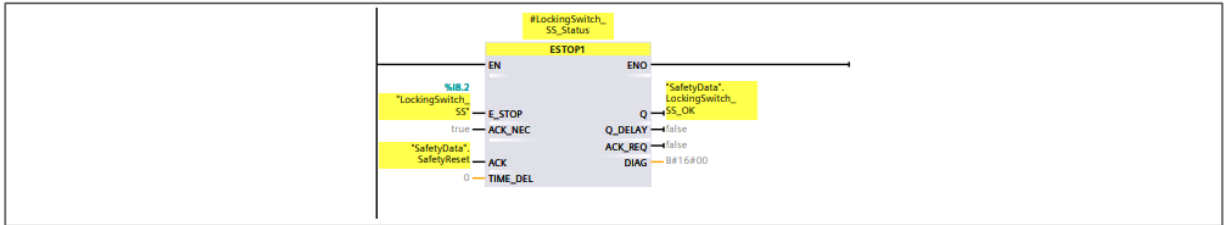
Network 4:



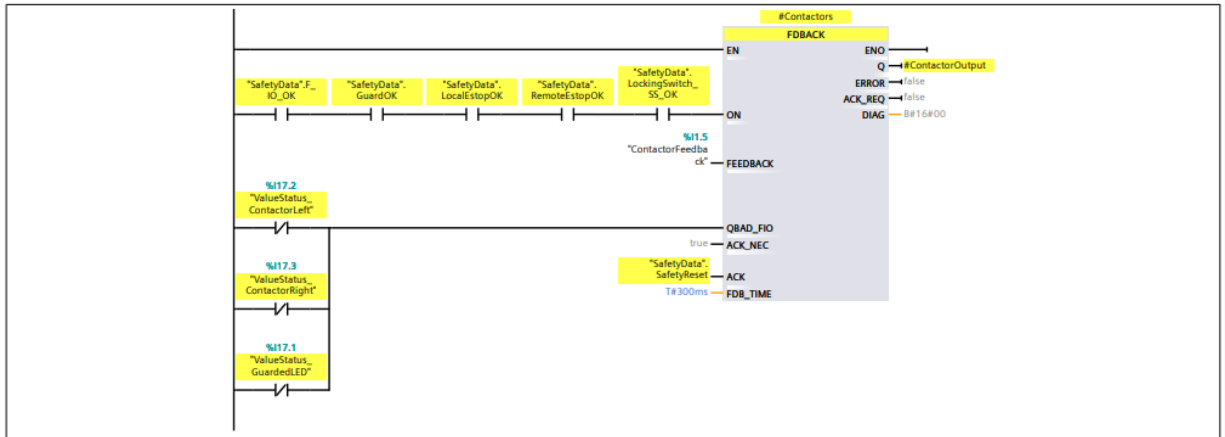
Network 5:



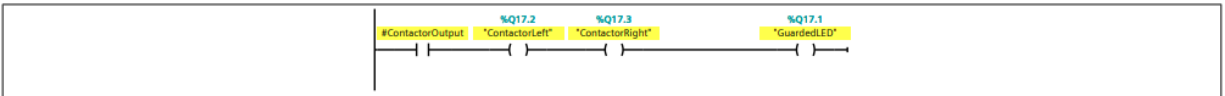
Network 6:



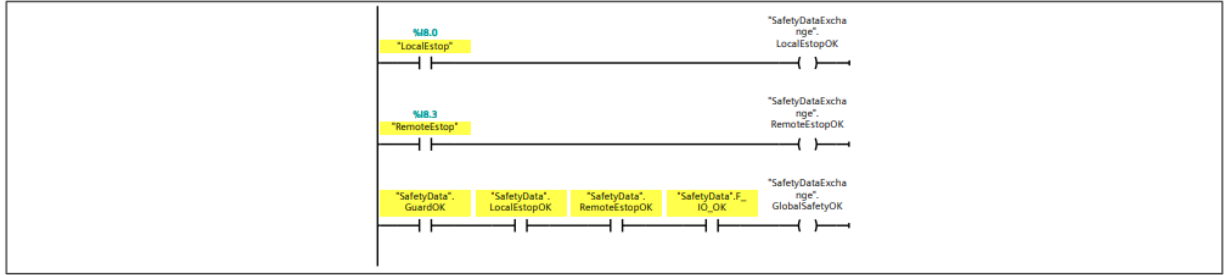
Network 7:



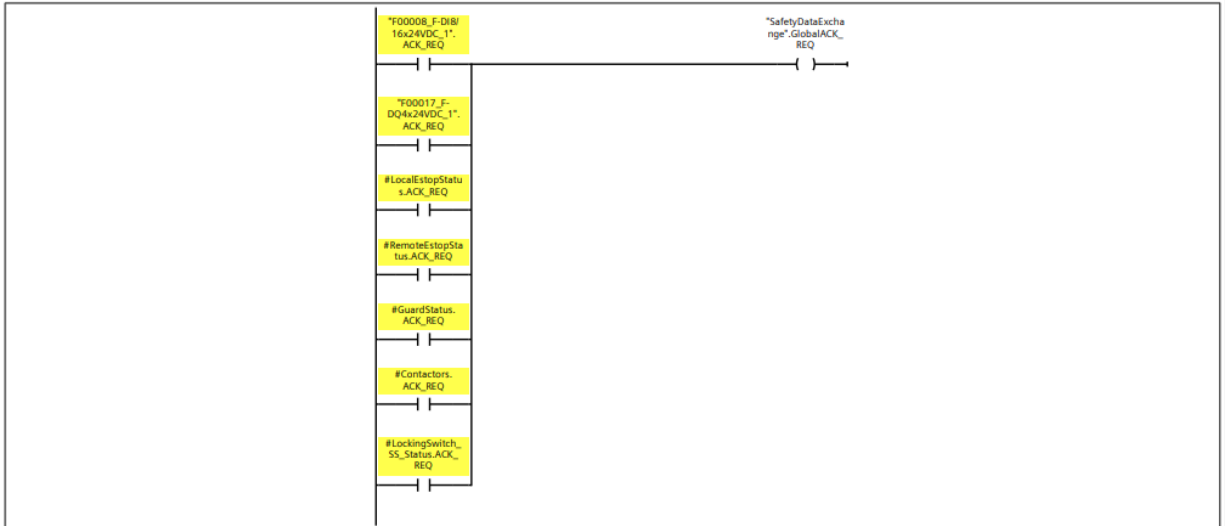
Network 8:



Network 9:



Network 10:



Program blocks

Main_Safety_RTG1_DB [DB1]

Main_Safety_RTG1_DB Properties									
General									
Name	Main_Safety_RTG1_DB	Number	1	Type	DB	Language	DB		
Numbering	Automatic								
Information									
Title		Author		Comment		Family			
Version	0.1	User-defined ID	FUSI						
Name	Data type	Start value	Retain	Accessible from HMI/OPC UA/Web API	Writeable from HMI/OPC UA/Web API	Visible in HMI engineering	Setpoint	Supervision	Comment
Input									
Output									
InOut									
▼ Static									
▼ ACK_GL_Instance	ACK_GL		False	True	True	True	True		
▼ Input									
ACK_GLOB	Bool	false	False	True	True	True	False		1=acknowledgment for reintegration
Output									
InOut									
Static									

▼ LocalEstopStatus	ESTOP1		False	True	True	True	True		
▼ Input									
E_STOP	Bool	false	False	True	True	True	False		Emergency STOP
ACK_NEC	Bool	true	False	True	True	True	False		1=Acknowledgment necessary
ACK	Bool	false	False	True	True	True	False		1=Acknowledgment
TIME_DEL	Time	0	False	True	True	True	False		Time delay
▼ Output									
Q	Bool	false	False	True	True	True	False		1=Enable
Q_DELAY	Bool	false	False	True	True	True	False		Enable is OFF delayed
ACK_REQ	Bool	false	False	True	True	True	False		1=acknowledgment request
DIAG	Byte	B#16#00	False	True	True	True	False		Service information
InOut									
Static									
▼ GuardStatus	ESTOP1		False	True	True	True	True		
▼ Input									
E_STOP	Bool	false	False	True	True	True	False		Emergency STOP
ACK_NEC	Bool	true	False	True	True	True	False		1=Acknowledgment necessary
ACK	Bool	false	False	True	True	True	False		1=Acknowledgment
TIME_DEL	Time	0	False	True	True	True	False		Time delay
▼ Output									
Q	Bool	false	False	True	True	True	False		1=Enable
Q_DELAY	Bool	false	False	True	True	True	False		Enable is OFF delayed
ACK_REQ	Bool	false	False	True	True	True	False		1=acknowledgment request
DIAG	Byte	B#16#00	False	True	True	True	False		Service information
InOut									
Static									
▼ RemoteEstopStatus	ESTOP1		False	True	True	True	True		
▼ Input									
E_STOP	Bool	false	False	True	True	True	False		Emergency STOP
ACK_NEC	Bool	true	False	True	True	True	False		1=Acknowledgment necessary
ACK	Bool	false	False	True	True	True	False		1=Acknowledgment
TIME_DEL	Time	0	False	True	True	True	False		Time delay
▼ Output									
Q	Bool	false	False	True	True	True	False		1=Enable
Q_DELAY	Bool	false	False	True	True	True	False		Enable is OFF delayed
ACK_REQ	Bool	false	False	True	True	True	False		1=acknowledgment request
DIAG	Byte	B#16#00	False	True	True	True	False		Service information
InOut									
Static									
▼ Contactors	FDBACK		False	True	True	True	True		
▼ Input									
ON	Bool	false	False	True	True	True	False		1=Enable output
FEEDBACK	Bool	false	False	True	True	True	False		Feedback input
QBAD_FIO	Bool	false	False	True	True	True	False		QBAD signal of FIO/channel of output Q
ACK_NEC	Bool	true	False	True	True	True	False		1=Acknowledgment necessary
Name	Data type	Start value	Retain	Accessible from HMI/OPC UA/Web API	Writ-able from HMI/OPC UA/ Web API	Visible in HMI engi-neering	Setpoint	Supervi-sion	Comment
ACK	Bool	false	False	True	True	True	False		Acknowledgment
FDB_TIME	Time	T#0ms	False	True	True	True	False		Feedback time
▼ Output									
Q	Bool	false	False	True	True	True	False		Output
ERROR	Bool	false	False	True	True	True	False		Feedback error
ACK_REQ	Bool	false	False	True	True	True	False		1=acknowledgment request
DIAG	Byte	B#16#00	False	True	True	True	False		Service information
InOut									
Static									
ContactorOutput	Bool	false	False	True	True	True	False		
▼ LockingSwitch_SS_Status	ESTOP1		False	True	True	True	False		
▼ Input									
E_STOP	Bool	false	False	True	True	True	False		Emergency STOP
ACK_NEC	Bool	true	False	True	True	True	False		1=Acknowledgment necessary
ACK	Bool	false	False	True	True	True	False		1=Acknowledgment
TIME_DEL	Time	0	False	True	True	True	False		Time delay
▼ Output									
Q	Bool	false	False	True	True	True	False		1=Enable
Q_DELAY	Bool	false	False	True	True	True	False		Enable is OFF delayed
ACK_REQ	Bool	false	False	True	True	True	False		1=acknowledgment request
DIAG	Byte	B#16#00	False	True	True	True	False		Service information
InOut									
Static									

Program blocks

SafetyData [DB2]

SafetyData Properties									
General									
Name	SafetyData	Number	2	Type	DB	Language	DB		
Numbering	Automatic								
Information									
Title		Author		Comment		Family			
Version	0.1	User-defined ID							
Name	Data type	Start value	Retain	Accessible from HMI/OPC UA/Web API	Writ-able from HMI/ OPC UA/ Web API	Visible in HMI engi-neering	Setpoint	Supervi-sion	Comment
▼ Static									
SafetyReset	Bool	false	False	True	True	True	False		
LocalEstopOK	Bool	false	False	True	True	True	False		
GuardOK	Bool	false	False	True	True	True	False		
RemoteEstopOK	Bool	false	False	True	True	True	False		
F_IO_OK	Bool	false	False	True	True	True	False		
LockingSwitch_SS_OK	Bool	false	False	True	True	True	False		

Program blocks

SafetyDataExchange [DB3]

SafetyDataExchange Properties									
General									
Name	SafetyDataExchange	Number	3	Type	DB	Language	DB		
Numbering	Automatic								
Information									
Title		Author		Comment		Family			
Version	0.1	User-defined ID							
Name	Data type	Start value	Retain	Accessible from HMI/OPC UA/Web API	Writ-able from HMI/ OPC UA/ Web API	Visible in HMI engi-neering	Setpoint	Supervi-sion	Comment
▼ Static									
GlobalACK_REQ	Bool	false	False	True	True	True	False		
GlobalSafetyOK	Bool	false	False	True	True	True	False		
LocalEstopOK	Bool	false	False	True	True	True	False		
RemoteEstopOK	Bool	false	False	True	True	True	False		

Program blocks / System blocks / STEP 7 Safety

F_SystemInfo_DB [DB30001]

F_SystemInfo_DB Properties									
General									
Name	F_SystemInfo_DB	Number	30001	Type	DB	Language	DB		
Numbering	Automatic								
Information									
Title		Author		Comment		Family			
Version	0.1	User-defined ID	F_GLOBDB						
Name	Data type	Start value	Retain	Accessible from HMI/OPC UA/Web API	Writ-able from HMI/ OPC UA/ Web API	Visible in HMI engi-neering	Setpoint	Supervi-sion	Comment
▼ Static									
FCCValue	DWord	16#0	False	True	True	True	False		

Program blocks / System blocks / STEP 7 Safety

RTG1SysInfo [DB30000]

RTG1SysInfo Properties									
General									
Name	RTG1SysInfo	Number	30000	Type	DB	Language	DB		
Numbering	Automatic								
Information									
Title		Author	SafeSys	Comment		Family	F_CTRL		
Version	2.2	User-defined ID	F_CTRL_1						
Name	Data type	Start value	Retain	Accessible from HMI/OPC UA/Web API	Writ-able from HMI/ OPC UA/ Web API	Visible in HMI engi-neering	Setpoint	Supervi-sion	Comment
Input									
▼ Output									
MODE	Bool	false	False	True	True	True	False		1 = deactivated safety mode
▼ F_SYSINFO	F_SYSINFO		False	True	True	True	False		F-Runtime group information
MODE	Bool	false	False	True	True	True	False		1 = deactivated safety mode
TCYC_CURR	DInt	0	False	True	True	True	False		current cycle time of the F-Runtime group in ms
TCYC_LONG	DInt	0	False	True	True	True	False		longest cycle time of the F-Runtime group in ms
TRTG_LONG	DInt	0	False	True	True	True	False		longest runtime of the F-Runtime group in ms
T1RTG_CURR	DInt	0	False	True	True	True	False		current runtime in ms for further use
T1RTG_LONG	DInt	0	False	True	True	True	False		longest runtime in ms for further use
F_PROG_SIG	DWord	DW#16#2B4F015	False	True	True	True	False		Collective F-signature of the safety program
▼ F_PROG_DAT	DTL	DTL#2021-4-1-19:20:26.508300200	False	True	True	True	False		Compilation date of the safety program
YEAR	UInt	2021	False	True	True	True	False		
MONTH	USInt	4	False	True	True	True	False		
DAY	USInt	1	False	True	True	True	False		
WEEKDAY	USInt	5	False	True	True	True	False		
HOUR	USInt	19	False	True	True	True	False		
MINUTE	USInt	20	False	True	True	True	False		
SECOND	USInt	26	False	True	True	True	False		
NANOSECOND	UDInt	508300200	False	True	True	True	False		
F_RTG_SIG	DWord	DW#16#1901059E	False	True	True	True	False		Collective F-signature of the F-Run-time group
▼ F_RTG_DAT	DTL	DTL#2021-4-1-19:20:26.508300200	False	True	True	True	False		Compilation date of the F-Runtime group
YEAR	UInt	2021	False	True	True	True	False		
MONTH	USInt	4	False	True	True	True	False		
DAY	USInt	1	False	True	True	True	False		
WEEKDAY	USInt	5	False	True	True	True	False		
HOUR	USInt	19	False	True	True	True	False		
MINUTE	USInt	20	False	True	True	True	False		
SECOND	USInt	26	False	True	True	True	False		
NANOSECOND	UDInt	508300200	False	True	True	True	False		
VERS_S7SAF	DWord	DW#16#16000000	False	True	True	True	False		Version label of STEP 7 Safety
InOut									
Static									

Program blocks / System blocks / STEP 7 Safety

F_ACK_GL [FB219]

F_ACK_GL Properties									
General									
Name	F_ACK_GL	Number	219	Type	FB	Language	FBD		
Numbering	Automatic								
Information									
Title	F_: Global acknowledgment of all F-I/Os in an F- Runtime group	Author	Safety	Comment		Family	F_FUNC		
Version	1.0	User-defined ID	F_ACK_GL						
Name	Data type	Default value	Retain	Accessible from HMI/OPC UA/Web API	Writ-able from HMI/ OPC UA/ Web API	Visible in HMI engi- neering	Setpoint	Supervi- sion	Comment
▼ Input									
ACK_GLOB	Bool	false	Non-retain	True	True	True	False		1=acknowledgment for rein- tegration
Output									
InOut									
Static									

QTY	ITEM	LIST PRICE/EA US\$ (CY-2021)	NET	DESC
1	6ES7214-1AF40-0XB0	\$ 730.00	\$ 730.00	CPU 1214FC (DC/DC/DC)
1	6ES7226-6BA32-0XB0	\$ 290.00	\$ 290.00	SM 1226 F-DI 16 x 24 VDC
1	6ES7226-6DA32-0XB0	\$ 290.00	\$ 290.00	SM 1226 F-DQ 4 X 24 VDC
2	3RH21222BB40	\$ 125.92	\$ 251.84	CONT.RELAY,2NO+2NC,DC24V
1	6EP1333-2BA20	\$ 198.00	\$ 198.00	SITOP PSU100S/1AC/24VDC/5A
1	3SU18010NE004AB2	\$ 144.15	\$ 144.15	E-STOP ENCLOSURE
1	3SU19000HG100AA0	\$ 12.78	\$ 12.78	Metric cable gland M20
3	3SU11020AB203CA0	\$ 77.10	\$ 231.30	PB 22MM FLUSH RED MOMENTARY ILL 24V LED 1NC SPRING TERM
3	3SU11020AB303BA0	\$ 77.10	\$ 231.30	PB 22MM FLUSH YELLOW MOMENTARY ILL 24V LED 1NO SPRING TERM
3	3SU11020AB403BA0	\$ 77.10	\$ 231.30	PB 22MM FLUSH GREEN MOMENTARY ILL 24V LED 1NO SPRING TERM
1	3SU11002BF603MA0	\$ 62.76	\$ 62.76	SEL SW 2POS 22MM MAINTAINED 1NO+1NC SPRING TERM
1	3RA2908-1A	\$ 33.93	\$ 33.93	TOOL SPRING TERMINALS
1	6ES7822-0AE06-0YA5	\$ 420.00	\$ 420.00	SIMATIC STEP 7 Basic V16 DL
1	6ES7833-1FB16-0YH5	\$ 235.00	\$ 235.00	STEP 7 Safety Basic V16 SW DL

To complete the project, wire the above and demonstrate that when the blue pb is pushed, the contactor turns on. This signifies a running system. To turn off the relays, turn on any of the four contacts that turn off the process. This includes the two emergency stops as well as the locking switch and the guard switch.

To add to the project and gain 2 additional points, provide a risk assessment and analysis using the BGIA/FIA example justifying the design. An analysis does not have to fit the program.



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