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TEST PROJECT DAY 2 / PROJET D'ÉPREUVE JOUR 2

INDUSTRIAL CONTROL

CONTRÔLE INDUSTRIEL

POST - SECONDARY /
NIVEAU POSTSECONDAIRE

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1. GENERAL DESCRIPTION

1.1 Contextualization

The Canadian Government has recently decided to overhaul and upgrade its fleet of Naval Frigates. As part of this maintenance overhaul, the artillery firing system will be upgraded to improve overall reliability, maintainability and improve overall mission performance.

The Trade 19 project represents the portion of the automated process for loading and positioning of ammunitions for firing in the naval ship 5-inch MK 45 on-board gun.

The auto-loading of ammunition is an integral part of the firing system and is critical for efficient mission success. The enhanced system upgrades to be introduced have been specifically tailored to allow the system to handle and fire high energy munitions, and to optimize performance and safety of new and existing ammunition types.

1.2 Terminology definition

1.2.1 Lit light

When a sequence describes a lit light, it means that light will be continuously ON.

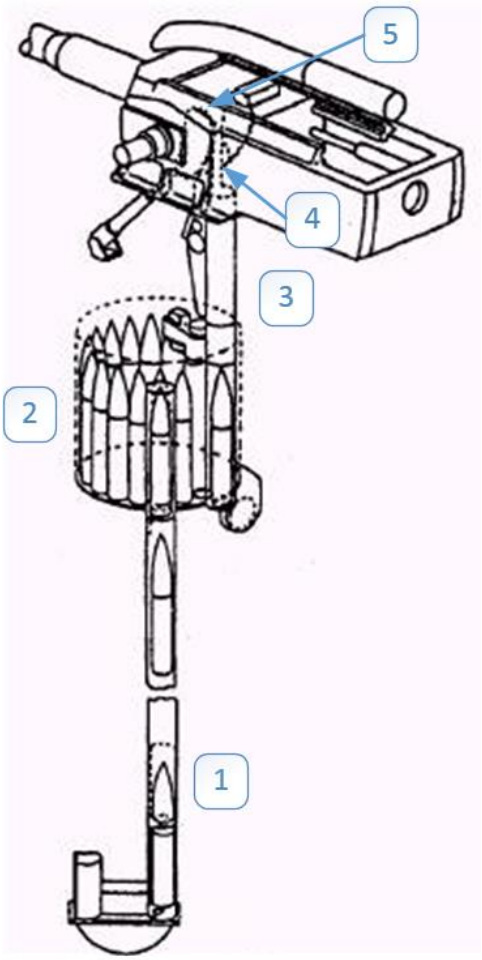
1.2.2 Flashing light

When a sequence describes a flashing light, it means that light will be cycling continuously ON for 1 sec and OFF for 1 sec

1.2.3 Fast flashing light

When the sequence describes a flashing light, it means that light will be cycling continuously ON for 0,5 sec and OFF for 0,5 sec

1.3 Process Diagram



1) Lower hoist
2) Loader drum
3) Upper hoist
4) Cradle
5) Breech

1.4 Process Equipment Function

This section describes the function of each component use in the process.

1.4.1 Tower stack lights (L1, L2 & L3)

The stack lights are used to indicate the process state.

1.4.1.1 Green stack light (L1)

This stack light is indicating the system is empty, and ready to load.

1.4.1.2 Amber stack light (L2)

This stack light is indicating a fault condition.

1.4.1.3 Red stack light (L3)

This stack light has dual purposes. In Manual mode it is used to show which step of the process the operator is on. Its second function is to also indicate that the process is ready to fire

1.4.2 White pilot light (L4)

This pilot light is indicating that power is available, and the system is running.

1.4.3 Maintained 3 position selector switch (SS1)

This selector will be used to select between manual operation (MAN), stopped process (OFF) or automatic operation (AUTO). The process will not start, or run, if the selector is in the center position (OFF).

1.4.4 Emergency Stop push-pull button (PB1A and B)

As described in material portion (Day 1) documentation, this button is activating the MCR/emergency Stop circuit, which de-energize all of the PLC's outputs.

1.4.5 Green Momentary Push button (PB2)

This push button will be used to start the process in either automatic or manual mode.

1.4.6 Red Momentary Push button (PB3)

This push button will be used to stop the process in either automatic or manual mode (in non-emergency condition).

1.4.7 Black Momentary Push button (PB4A and PB4B)

This push button will be used to reset the process in either automatic or manual mode.

1.4.8 Red illuminated Momentary Push button (PBL5)

This push button will be used to fire ammunition, This pilot light will be used for the same purpose as the Red stack light as it this is to indicate process status in the field.

1.4.9 3 Pole Contactor (K1)

This contactor is feeding the loader drum motor (M1) and it is equipped with a thermal overload relay (K1_OL).

1.4.10 3 Pole Contactor (K2)

This contactor is feeding the breech motor (M2) and it is equipped with a thermal overload relay (K2_OL).

1.4.11 3 Pole Forward-Reverse Contactor (K3)

This contactor is feeding the bidirectional upper hoist motor (M3) and it is equipped with a thermal overload relay (K3_OL). The Forward direction brings ammunition to the cradle while the reverse brings the upper hoist back to the drum.

1.4.12 Variable Frequency Drive (VFD)

This inverter is feeding the lower hoist motor (M4). The Forward direction brings ammunition to the drum while the reverse brings the lower hoist to the loading position.

1.4.13 Inductive proximity switch (PE1 to PE3)

These are used to detect the presence of a shell in the loader drum, upper hoist and cradle

1.4.14 Limit switches (LS1 to LS4)

These are used to detect the lower and upper hoist positioning.

1.4.15 Solenoids (SOL1 and SOL2)

The solenoids are used for feeding the loader drum (SOL1) and the cradle (SOL2)

2 Off Mode Description

When the mode selector (SS1) is in the center position (OFF), all the outputs will be de-energized except for the white pilot light (L4). This output shall always be activated at all times (including when process is stopped), which will result in having the pilot light constantly lit as long as the emergency stop button is not pressed.


DOCUMENT USE

3 Manual Mode Description

The purpose of the Manual mode is to enable the operator to manually operate each motor and solenoid individually

3.1 Initialisation and process start

In order to start the process in Manual mode, the selector switch SS1 must be in the Manual position (MAN), and no fault must be detected. If a fault is present, the amber stack light (L2) will light, if not, the green stack light (L3) will flash instead announcing to the operator that the process is ready to start in manual mode. All other outputs are un-activated except for the white pilot light (L4).

Once in manual mode and with the green stack light flashing, the operator will push the green push button (PB2) start the manual mode process.

3.2 Manual process

Once the manual mode is started:

- The operator will press the green push button (PB2) again to advance through each of the steps. The red stack light (L3) will flash the number of times corresponding to each step. When the black push button (PB4 A/B) is pushed, the device corresponding with the steps in Table 1 will operate. Pushing the button more than once in each step will toggle the device (i.e. pushing the black push button once in step 1 will raise the lower hoist, pushing the black push button a second time will lower the lower hoist).

Table 1

Step Number	Red Stack Light (L3) Flash Sequence
Step 0 Initial step when placed in manual	Red Stack Light off
Step 1 Lower Hoist	On for 1 second, off for 3 seconds
Step 2 Loader Drum Feeder Sol	Flash 2 times at 1 second intervals, off for 3 seconds
Step 3 Loader Drum	Flash 3 times at 1 second intervals, off for 3 seconds
Step 4 Upper Hoist	Flash 4 times at 1 second intervals, off for 3 seconds
Step 5 Cradle Solenoid	Flash 5 times at 1 second intervals, off for 3 seconds
Step 6 Breech	Flash 6 times at 1 second intervals, off for 3 seconds

3.3 System stop

To normally stop the process, the operator need to press the red push button (PB3) and the following will occur:

- When the red push button (PB3) is pushed during the Manual process, any outputs that are on will turn off
- Pressing the green push button (PB2) after the red push button (PB3) has been pressed will reset Manual process to Step 0
- Pressing the black push button (PB4A/B) after the stop button has been pushed will resume the Manual process where it left off when the red push button was pushed
- Selecting the Man/Off/Auto to Off will turn off all outputs and reset the Manual process to Step 0
- If one of the hoists is in mid-position when the Manual process is reset to Step 0, the operator must manually select the proper step and return the hoist back to its starting position

4. Automatic Mode

The purpose of the Automatic mode is to allow the ammunition loading processes to work automatically without the supervision of any operator.

4.1 Initialisation and process start

In order to start the process in Automatic mode, the selector switch SS1 must be in the Auto position, and no fault must be detected. If a fault is present, the amber stack light (L2) will light, if not, the green stack light (L1) will flash fast instead announcing the operator that the process is ready to start in auto mode. All other outputs are un-activated except for the white pilot light (L4).

Before starting the process in automatic mode, the operator must press the green push button (PB2).

4.2 Automatic process

Once the automatic mode is started:

- The amber stack light (L2) will be de-energized
- The green stack light (L1) will light
- The Lower Hoist (VFD02) will run in forward until LS2 is made
- If LS2 is not made within 5 seconds of (VFD02) starting a fault must occur, and in order to continue the process the fault must be cleared and the process will resume where it left off.
- Once LS2 is made the Lower Hoist (VFD02) will stop the forward direction
- The Solenoid SOL1 will be activate for 1 second to push the shell into the loader drum
- The Lower Hoist (VFD03) will run in reverse until LS1 is made
- If LS1 is not made within 5 seconds of (VFD03) starting a fault must occur, and in order to continue the fault must be cleared and the process will resume where it left off.
- Once LS1 is made the Lower Hoist (VFD03) will stop the reverse direction
- Optical Sensor (PE1) will detect the shell in the loader drum
- The Loader Drum (K1) will start and run and the shell will be mechanically ejected from the loader drum into the Upper Hoist.
- The Optical Sensor (PE2) will detect the shell loaded into the Upper Hoist.
- Lower Hoist (VFD02) can now start over and begin loading another shell
- Upper Hoist (K3F) starts and advances shell until LS4 is made
- When LS4 is made the shell can then enter the cradle
- For the purpose of this exercise the positions of the “cradle” are as follows:
    - When SOL2 is De-energized the cradle is down
    - When SOL2 is Energized the cradle is up

- When Upper Hoist (K3F) has made LS4 the cradle can energize and align the shell with the chamber
- The Breech Motor (K2) will engage and then feed the shell into the into the loaded position
- When the Breech Motor (K2) engages the cradle will de-energize after 3 seconds and the Upper Hoist (K3R) will engage until LS3 is made allowing new shell to enter the upper hoist.
- After the Breech Motor (K2) has ran for 5 seconds the Red Illuminated Push Button (PBL5) will light and the button can be pressed for fire.
- When the Red Illuminated Push Button (PBL5) is pressed the buzzer (BZ) will sound letting everyone know the gun has fired. After the process is complete it will start again at the push of the Green Push Button (PB2) as long as no faults are present.

5. Emergency stop

In both manual or automatic mode, upon the activation (push) of one of the emergency stop buttons (PB1A or PB1B):

- All motors will stop (outputs are turned off)
- The solenoids (SOL1 & SOL2) will be de-energized
- The green stack light (L1) will turn off

When all the E-stop button (PB1A or PB1B) will be pulled back to their non-activated state

- The amber stack light (L2) will flash fast to warn the operator that the process needs to be reset

As long as the emergency stop button is pushed, the operator won't be able to reset the process.

Once the emergency stop button is pulled, no motor should run, the operator will be able to reset the process using the black push button (PB4A/B).

Once the process is reset, the amber stack light (L2) will become lit, indicating that the manual mode is back to its "ready to start" state; which means the operator can start the process again by pressing the green push button (PB2).

Note that another condition, such as fault detection may prevent the user to reset the process.

6. Fault detection

In both manual or automatic mode, upon a detection of a VFD fault or an overload trip:

- All motors will stop
- The solenoid (SOL1 & SOL2) will be de-energized
- The green stack light (L1) will be de-energized
- The red stack light (L3) will light to warn the operator of the presence of a fault
- The amber stack light (L2) will flash to warn the operator that the process needs to be reset

For long as the fault detection remains, the operator won't be able to reset the process.

Once the fault condition is cleared, the red stack light (L2) will be turned off and the operator will be able to reset the process using the black push button (PB4A/B).

Once the process is reset, the amber stack light (L2) will become lit, indicating that the manual mode is back to its "ready to start" state; which means the operator can start the process again by pressing the green push button (PB2).

Note that another condition, such as emergency stop may prevent the user to reset the process.

7. Inputs and outputs table

The following tables are a recommended assignment of the inputs and outputs for your programmable control. As controllers vary in how they are connected and function, you must check your particular PLC to see if these assignments are suitable.

7.1 Inputs

Input Detail	Symbol	Contact Type	PLC inputs Assignment	Information supplied at state (1)
Master Control Relay / Emergency Stop Circuit	MCR	NO	In0	E-Stop Button not pressed
Green push button	PB2	NO	In1	Button pressed
Red push button	PB3	NC	In2	Button not pressed
Black push buttons	PB4A/B	NO	In3	Button pressed
3 positions Selector Switch 1 - Left Position	SS1_1	NO	In4	Selector in MAN position (Left)
3 positions Selector Switch 1 - Right Position	SS1_3	NO	In5	Selector in AUTO position (Right)
Illuminated Red push button	PBL5	NO	In6	Button pressed
Contactor K1, K2, K3 Overloads	K_OL	NO	In7	Overload tripped
VFD fault	VFD_FLT	NO	In8	VFD in fault
Optical sensor 1	PE1	NO	In9	Proximity switch activated
Optical sensor 2	PE2	NO	In10	Proximity switch activated
Optical sensor 3	PE3	NO	In11	Proximity switch activated
Limit switch 1	LS1	NC	In12	Limit switch not activated
Limit switch 2	LS2	NC	In13	Limit switch not activated
Limit switch 3	LS3	NC	In14	Limit switch not activated
Limit switch 4	LS4	NC	In15	Limit switch not activated

7.2 Outputs

Output Detail	Symbol	PLC outputs Assignments	Action at state (1)
Green stack light	L1	Q0	Light ON
Amber stack light	L2	Q1	Light ON
Red stack light	L3	Q2	Light ON
Illuminated Red push button	PBL5	Q3	Light ON
Buzzer	BZ	Q4	Buzzer ON
Contactor K1	K1	Q5	Contactor activates
Contactor K2	K2	Q6	Contactor activates
Contactor K3 Forward	K3_F	Q7	Contactor activates
Contactor K3 Reverse	K3_R	Q8	Contactor activates
Solenoid 1	SOL1	Q9	Solenoid activates
Solenoid 2	SOL2	Q10	Solenoid activates
VFD Digital Input 02 (Forward command)	VFD02	Q11	Motor running forward
VFD Digital Input 03 (Reverse command)	VFD03	Q12	Motor running reverse