ENEL 380 Project Report

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I. Overview of System/Process

The system for this project is a parking barrier system. The parking barrier system in this design uses a mechanical arm that allows entry and exit to various secure locations. Furthermore, the system also incorporates the use of a RFID (radio-frequency identification) sensor to allow the system to work automatically. The process of this system starts with the arrival of the car and then the RFID sensor will read the tag that is present in the car. Once it reads the tag and finds the tag valid, the system will operate the motor to raise the arm thus allowing the car to pass through. In the end, the system will return to its original state.

II. Design Constraints and Considerations

Design Constraints

There are three constraints that were considered for this system:

1. The system should be able to function without being affected by environmental factors such as wind, rain, etc.
2. The system can only be used in commercial privates such as hotels, Casinos, etc.
3. The system cannot be used for large commercial vehicles such as trucks, trailers, etc.

Safety Considerations

There are three general safety considerations that were recognized for this system and this is how each safety consideration is addressed:

1. The condition when the arm is forcibly moved. In this situation, an alarm would turn on and a reset button is required to turn off the alarm and reset the system.
2. The condition when there is an object underneath the arm while the reverse motor is on and the arm is going down. In this situation, the arm would stop moving with the alarm turning on remaining on until the object underneath is no longer detected.
3. The condition when there is a power outage. In this situation, it is under the assumption there would be a backup generator or some type of battery power that is going to be used to continue the operation.

Budgetary Concerns and Assumptions

1. Using an RFID can be more costly than a simple keypad with passwords. However, easier as well as more secure than having to manually enter a password everytime.
2. The RFID will also be cheaper to operate over hiring someone to manually operate the arm because the sensors are assumed to be very reliable.
3. Force switch is assumed to only go off when enough force is applied in the upward direction, to reduce the chances of environmental factors, such as wind blowing it.

III. Components of the System

Arrival Sensor and Arm Sensor (Through Beam Sensor)

The arrival and arm sensors objective is to detect whether or not there is a car passing through some critical spots of the system. The arrival sensor is located a few meters from the barrier preventing the arm to be opened without having any vehicles there. The arm sensor is located in the same struct that holds the barrier preventing the arm to be closed if there is any object in its way. There are four primary requirements for these sensors:

- Capability of detecting objects in a 4 meters range
- Reliability and durability of working in outdoor environments
- Operating voltage less or equal to 24 volts
- Maximum current less or equal to 300 miliamperes

To achieve the requirements mentioned above a photoelectric sensor was selected. A photoelectric sensor is a component that uses a light transmitter, often infrared, and a photoelectric receiver, which can measure the distance or detect the presence of an object. There are three different types: opposed (through beam), retro-reflective, and proximity-sensing (diffused).

Photoelectric sensors are widely used in industrial applications and it is very common to find them in parking control systems since they are cheap and easy to install. Among the types of photoelectric sensor, the through beam is the one that best fits this project due to its better accuracy, its capability of performing long range detections, as well as its capability of working under environmental influences, such as sunlight.

For this project the emitter C18E-00-1A and the receiver C18R-0N-1A were chosen, since they meet the requirements as it will be shown in the specifications below.

Figure 1.a) Receiver

Figure 1.b) Emitter

Specifications	Diffuse Models	Diffuse Models with Background Suppression	Reflective Models	Through-beam Models
Type	Diffuse	Diffuse with background suppression	Polarized reflection	Through-beam[1]
Sensing Distance	600 mm (23.62in)[2]	10 to 120 mm (0.39 to 4.72 in)[3]	2 m (6.6 ft)	6 m (19.7 ft)
Emission	LED red (660nm)	LED red (660nm)	LED red polarized (660 nm)	LED red (660nm)
Light Spot Diameter	See charts			
Sensitivity	Adjustable one-turn pot.		–	
Output Type	NPN or PNP; 1 L.O. and 1 D.O.	NPN or PNP; L.O. only	NPN or PNP; D.O. only	NPN or PNP; 1 L.O. and 1 D.O.
Operating Voltage	10-36 VDC			
No Load Supply Current	20 mA	25 mA	15 mA	Receiver: 10 mA Emitter:15 mA
Operating (Load) Current	≤200 mA			
Off-state (Leakage) Current	≤10μ A			
Voltage Drop	≤2.0 V			
Switching Frequency	1kHz	500Hz	1kHz	1kHz
Ripple	≤20%			
Time Delay Before Availability (tv)	60ms	20ms	20ms	20ms
Short-Circuit Protection	Yes (switch autoresets after overload is removed)			
Operating Temperature Range	-25° to + 55°C (-13° to 131°F)			
Protection Degree (DIN 40050)	IEC IP67			
LED Indicators - Switching Status	Yellow (output state, output energized), green (excess light indication). Emitter has no LED			
Housing Material	Chrome-plated brass			
Lens Material	Glass			
Shock/Vibration	See terminology section			
Tightening Torque	50 Nm (36.88 lb-ft)			
Weight	65.22 g (2.3 oz).			
Connectors	2m (6.5') axial cable; M12 (12mm) connector			
Agency Approvals	UL file E328811			

Notes: [1]Through-beam sensors must be used in pairs consisting of one receiver and one emitter. [2]With 200x200mm white matte paper. [3]With 100x100mm white matte paper.

Table 1. Through beam sensor specifications

As it is possible to see in Table 1, the sensing distance is 6 meters, the operating voltage and current are 10-36 VDC and 200mA respectively, meeting all the established criterias. The images below, Figure 2, a and b, show the wiring diagrams for both emitter and receiver.

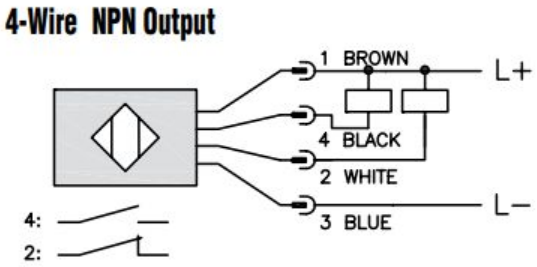


Figure 2.a) Receiver

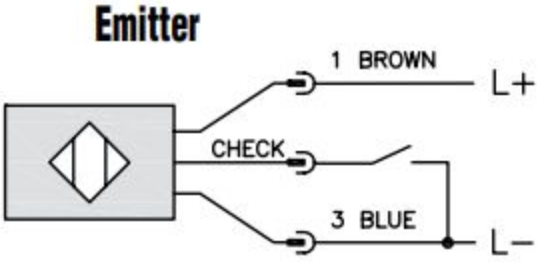


Figure 2.b) Emitter

The price for the C18R-0N-1A (Receiver) is 50 CND and C18E-00-1A (Emitter) is 36 CND, so it is a total of 86 CND for each pair.

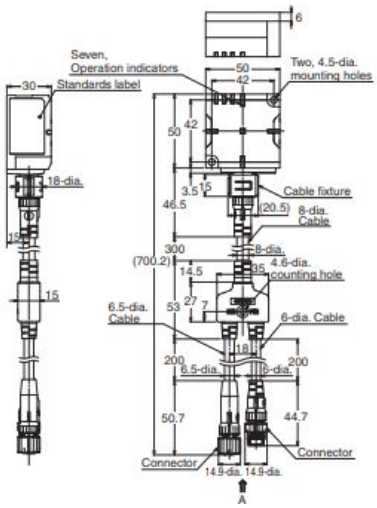
RFID (Radio-Frequency Identification) Sensor

The RFID sensor will be used to guarantee that only those allowed have access to the private area. This sensor will be located in the same struct that holds the arrival sensor. The requirements for the RFID are:

- Capability of connecting with the PLC
- Operating voltage less or equal to 24 volts
- Maximum current less or equal to 300 miliamperes

RFID uses electromagnetic fields to automatically identify tags attached to objects. When you bring the tag closer to the base it will identify the tag by receiving data, similar to a barcode. Via an Ethernet Cable, the base will send this data to the PLC which will then be able to recognize if it is an allowed user. The RFID model that met the requirements is V680S-HMD63-EIP, Figure 3.

V680S-HMD63-EIP
V680S-HMD63-PNT



Mounting Hole Dimensions

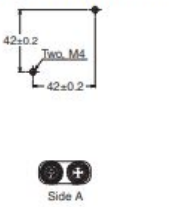


Figure 3. RFID - V680S-HMD63-EIP

It is possible to see in Table 2 all the specifications for the selected RFID. The most important information is, that it is a Reader/Writer that uses EtherNet communication, the power supply voltage is 24 VDC and the maximum current consumption is 200 milliamperes.

Reader/Writer
EtherNet/IP, PROFINET

Item / Model	V680S-HMD63-EIP V680S-HMD63-PNT	V680S-HMD64-EIP V680S-HMD64-PNT	V680S-HMD66-EIP V680S-HMD66-PNT
Dimensions	50W × 50H × 30D (excluding protruding parts and cables)	75W × 75H × 40D (excluding protruding parts and cables)	120W × 120H × 40D (excluding protruding parts and cables)
Power supply voltage	24 VDC (−15% to +10%)		
Consumption current	0.2A max.		
Ambient operating temperature	−10 to +55 °C (with no icing)		
Ambient operating humidity	25% to 85% (with no condensation)		
Ambient storage temperature	−25 to 70 °C (with no icing)		
Ambient storage humidity	25% to 85% (with no condensation)		
Insulation resistance	20 MΩ min. (at 500 VDC) between cable terminals and case		
Dielectric strength	1,000 VAC, 50/60 Hz for 1 min between cable terminals and case		
Vibration resistance	No abnormality after application of 10 to 500 Hz, 1.5-mm double amplitude, acceleration: 100 m/s², 10 sweeps in each of 3 axis directions (up/down, left/right, and forward/backward) for 11 minutes each		
Shock resistance	No abnormality after application of 500 m/s², 3 times each in 6 directions (Total: 18 times)		
Degree of protection	IP67 (IEC 60529: 2001) Oil resistance equivalent to IP67F (JIS C 0920: 2003, Appendix 1) *		
Materials	Case: PBT resin, Filled resin: Urethane resin		
Mass	Approx. 240g	Approx. 390g	Approx. 760g
Installation method	Reader/Writer: Two M4 screws (Use a screw of 12 mm or more in length.) Branch cable joint: One M4 screws	Four M4 screws (Use a screw of 12 mm or more in length.)	
Host device communications interface	Ethernet 10BASE-T/100BASE-TX		
Host device communications protocol	EtherNet/IP, PROFINET		
Accessories	Instruction Sheet, Description of Regulations and Standard, IP address label		

Table 2. V680S-HMD63-EIP Specifications

The price that we found for this component is 2,264 CND, which is very expensive. We believe that the component that we are using for our design function is greater than needed for our requirements. However, we could not find a model that was simpler and cheaper that would connect to the PLC.

Remote Push buttons

The remote push button will be located at the worker or employees discretion, whether directly beside the arm barrier, or inside the building. The push button was implemented for ease of use as well as a convenience for those needing to use it. The push button will be needed and used when either wanting the gate to be manually opened, manually closed, or needed in order to reset the alarm after going into the forced state by someone applying pressure to the arm. The requirements for the remote push button are:

- Capability of connecting with the PLC through radio frequency signals
- Capability of great communications distance (at least 20m)
- Quick response time from the push button to PLC
- Head Unit or Master Unit having an operating current less than or equal to 300 milliamperes
- At least three different outputs available
- Operating voltage less or equal to 24 volts

Remote push buttons work when the slave buttons are pressed sending signals using radio frequency waves to the head unit, which then in turn sends a confirmation signal back to the slave button. The remote push button that our group decided to go with for the project was one designed by Omron and is the A2W series. When looking further into the push button models, the only difference is the button type, mushroom or full guard, as well as the colour coding of button and flange. Every model under the A2W series operates at the same frequency of 922.5MHz. Due to our group wanting a more sophisticated look, we chose to go with the A2W-TC-WC1 US1BB model for the button type due to being a simple mushroom push button as well as having a black button and flange. As for the head unit, we went with the A2W-RCN-WC1 US model. The only difference between models is the one that we chose has a sinking output, and the other is sourcing. Shown in Table 3, all the wireless specifications meet our requirements regarding the transmission or broadcast of the signal. The wireless interface has a quick transmission time, approximately 3 milliseconds, great communication distance,

which is around 100 meters outdoors, as well as having the capability of connecting with the PLC through radio frequency signals.

Wireless Specifications

Item		
	Slave button model	A2W-TC-WC1□□□□□
	Master Unit model	A2W-RC□-WC1 □□
Set frequency		922.5 MHz
Frequency channels		1 channel
Transmission power		50 mV/m max.
Wireless service area communications speed		100 kbit/s
Communications method		Simplex communications
Number of wireless pushbuttons connected		8 max.
Communications distance (line of sight)		Approx. 100 m outdoors (with the included pencil antenna)
Transmission time		Approx. 3 ms (from Slave button transmission to Slave button reception)
Repeater function		Not supported.

Table 3. Wireless specifications of remote push button

Slave button

Ratings

Item	Specifications
Operating force	25 N max.
Number of operations	1,000,000 operations
Vibration resistance	Frequency: 10 to 55 Hz, half amplitude: 0.75 mm Sweep 5 min, 2 h
Shock resistance	1,000 m/s^2 Direction: 3-axis, 6 directions
Ambient operating temperature range	-10 to +55°C (no condensation or freezing)
Ambient operating humidity range	20% to 90%, (no condensation)
Atmosphere	No corrosive gas
Storage temperature range	-40 to +70°C (no condensation or freezing)
Storage humidity range	20% to 90%, (no condensation)
Degree of protection	IP65
Altitude	2,000 m max.
Weight	100 g max.

Table 4. Slave button specifications

As shown in Table 4 there are certain slave button specifications that are important such as the storage temperature range if living in a cold or hot environment so that if the button is placed outside it will still remain operational. In Table 5, the rest of the requirements were met operating at 24 volts, having at least three different outputs, we have eight, having an operating current less than or equal to 300 milliamperes, where ours is 100 milliamperes, as well as quick response time, where ours is roughly 30 milliseconds.

Master Unit

Ratings

Item		Specifications
Master Unit power supply	Rated voltage	24 VDC
	Allowable voltage range	21.6 to 26.4 VDC
	Power consumption	2.4 W max.
	Input current	0.1 A max.
Output rated	Output points	Output 8 points One other point for error output
	Output circuit shared voltage	30 VDC max.
	Maximum load current	50 mA per point
	Leakage current	0.1 mA max.
	Residual voltage	2.0 V max.
	Output logic	One-shot (500 ms)
	Response time	30 ms or less (from Slave button transmission to Master Unit signal output)
	Number of connected Slave buttons	8 max.
Error clear terminal	Residual voltage at short	1.5 V or less, ON
	Leakage current	0.1 mA or less, OFF (current at short: approx. 7 mA)
Insulation resistance		20 MΩ max. (100 VDC) Between the case and power supply terminals and all outputs terminals Between all power supply terminals and all outputs terminals
Dielectric strength		1,000 VAC, 1 min. Between the case and power supply terminals and all outputs terminals Between all power supply terminals and all outputs terminals
Vibration resistance		Frequency: 10 to 55 Hz, half amplitude: 0.42mm 3-Directional, 120 minutes each (1 sweep, 1 min. ×120 sweeps)
Shock resistance		150 m/s² Direction of shock: 3-axis, 6 directions Shock frequency: 3 × each direction, total 18
Ambient operating temperature range		-10 to +55°C (no condensation or freezing)
Ambient operating humidity range		20% to 90% (no condensation)
Surrounding atmospheric conditions		No corrosive gas
Ambient storage temperature range		-40 to +70°C (no condensation or freezing)
Ambient operating humidity		20% to 90% (no condensation)
Degree of protection		IP20
Altitude		2,000 m max.
Memory protection		Non-volatile memory (Number of write operations: 1,000,000)
Weight		150 g (not including antenna) 160 g (including antenna)
Mounting		DIN rail mounting Screw mounting

Table 5. Master unit specifications

The price for each push button appears to be around 442 CND and we would be needing three of them making it around 1,326 CND. Additionally, the master units cost is approximately 1,096 CND. Therefore, in the end the remote push button setup would cost 2,422 CND.

Limit Switches

The limit switches will be used to inform the system when the arm has reached its upper and lower limits, so that the motor should shuts off when needed. Limit switches are a very simple

component, the main requirement is to be able to operate with the voltage and current from the PLC. As written in the specifications, the selected switch can handle way more than the minimum requirement. The switch that we will be using in our project is E47BMS20, Figure 4.

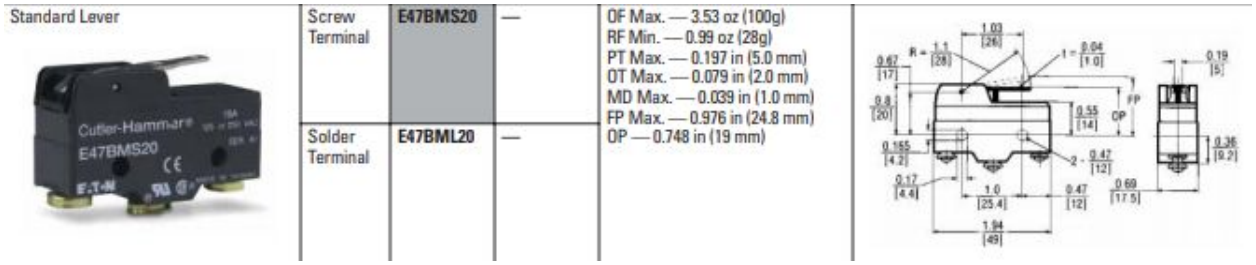


Figure 4. Limit Switch E47BMS20

Table 6 contains general information about the E47BMS20 limit switch.

Specifications

Operating Speed	0.01m/second to 1m/second
Operating Frequency Mechanical Electrical	 120 Operations/minute 20 Operations/minute
Mechanical Life	3,000,000 Operations minimum
Electrical Life	500,000 Operations minimum
Contact Resistance	15m Ohms maximum, initial
Insulation Resistance	100m Ohms minimum @ 500V DC
Dielectric Strength Between Non-current Carrying Parts Between Current Carrying Parts and Ground	 1000V AC, 50/60 Hz for 1 minute 2000V AC, 50/60 Hz for 1 minute
Ambient Operating Temperature Basic Enclosed	 -13° to 176°F (-25° to 80°C) 5° to 176°F (-15° to 80°C)
Environmental Rating Enclosed, Booted	 NEMA 1
Mounting Centers	1.0 in (25.4 mm), #8 screw size
Terminal Screws	Bottom facing M4 x 0.7 (8 – 32) — Screws with cup washers will accept 22 – 12 AWG (2.5 sq. mm maximum) Maximum Torque: 10 in-lbs.
Threaded Bushing	15/32 in
Material of Construction	Mineral filled phenolic
Enclosure Rating	Aluminum die casting (ADC-3/A380); Seal boot: Nitrile, butyl rubber (NBR)
Conduit Fitting On Enclosed Type	1/2 inch NPT

Table 6. Limit Switch General Specification

Table 7 contains information about voltage and current ratings. The E47BMS20 is a 15 amperes and can handle up to 250 VDC if need be.

Ratings ①②

Model	Rated Voltage (V)	Non-inductive Load (A)			Inductive Load (A)			Inrush Current (A)	
		Resistive Load	Lamp Load		Inductive Load	Motor Load			
		N.C. and N.O.	N.C.	N.O.	N.C. and N.O.	N.C.	N.O.	N.C.	N.O.
15A	125V AC	15	3	1.5	15	5	2.5	30 Max.	15 Max.
	250V AC	15	2.5	1.25	15	3	1.5		
	500V AC	3	1.5	0.75	2.5	1.5	0.75		
	8V DC	15	3	1.5	15	5	2.5		
	14V DC	15	3	1.5	10	5	2.5		
	30V DC	6 (2)	3	1.5	5	5	2.5		
	125V DC	0.4	0.4	0.4	0.05	0.05	0.05		
	250V DC	0.2	0.2	0.2	0.03	0.03	0.03		

Table 7. Limit Switch Voltage and Current Specifications

Force Switch(Pressure Sensor)

We have implemented a force switch into our design so that if someone is to be either hit by the arm or manually try and lift it, it will activate the force switch to sound the alarm. The requirements for the pressure sensor are the same as most. Being that it must have an operating current of 300 milliamperes or less and voltage of 24 volts or less. The force switch that we chose is produced by SMC and is the ISE1 series and the ISE1-01-14 model, which can be seen in Figure 5.

Figure 5 - ISE1-01-14 Pressure Sensor

As shown in Table 8, all of the general specifications such as rated pressure range, temperature characteristics, and the weight are included. When examining the specifications of the force

switch shown in Table 8, there is also the current consumption of 17 milliamperes or less when at 24 volts DC. The power supply voltage is between 12 to 24 volts DC.

Model		ZSE1	ISE1L	ISE1
		For vacuum	For low pressure	For high pressure
Rated pressure range/Set pressure range		0 to –101 kPa	0 to 100 kPa	0 to 1 MPa
Expanded analog output range		10 to 0 kPa	–10 to 0 kPa	–0.1 to 0 MPa
Proof pressure		500 kPa		1.5 MPa
Fluid		Air/Non-corrosive, non-flammable gas		
Power supply voltage		12 to 24 VDC ±10%, Ripple (P-P)10% or less (With power supply polarity protection)		
Current consumption		1 output: 17 mA or less at 24 VDC, 2 output: 25 mA or less at 24 VDC		
Response time		5 ms or less		
Repeatability		±1% F.S. or less		
Resistance	Enclosure	IP40		
	Operating temperature range	Operating: 0 to 60°C, Stored: –10 to 60°C (With no condensation and no freezing)		
	Operating humidity range	Operating/Stored: 35 to 85%RH (With no condensation)		
Temperature characteristics (Based on 25°C)		±3% F.S. or less		
Withstand voltage		1000 VAC for 1 min. (between terminals and housing)		
Insulation resistance		50 MΩ or more (500 VDC measured via megohmmeter) between terminals and housing		
Port size		01: R 8, M5 x 0.8 T1: NPTF 1/8, M5 x 0.8 00: ZM ejector mount type		
Weight		40 g (Including 0.6 m-Long lead wire)		
Lead wire	Grommet type	Oilproof heavy-duty vinyl cable 3 cores, ø3.4, Conductor area: 0.2 mm², Insulator O.D.: 1.1 mm		
	Connector type	Heat-resistant vinyl electric wire, 4-wire, Conductor area: 0.3 mm², Insulator O.D.: 1.55 mm		
Standard		CE, RoHS		

Table 8. General specifications of the different force switch models

Table 9 shows more information of what type of force switch it is.

Output Specifications

Model	-14	-15	-16	-17	-18	-19	-55
Switch output	NPN open collector 30V, 80 mA or less						PNP open collector 80 mA or less
Residual voltage	1V or less (With load current of 80 mA)						
Number of outputs	1		2		1		
Hysteresis	1 to 10% of set prss. (Variable)		3% F.S. or less (Fixed)		1 to 10% of set prss. (Variable)		1 to 10% of set press. (Adjustable)
Indicator light	ON: when output is ON (Red)		ON: when output is ON (OUT1: Red, OUT2: Green)		ON: when output is ON (Red)		
Trimmer adjustment	3 turns	200 degrees	3 turns	200 degrees	3 turns	200 degrees	
Analog output	None				1 to 5 V ±5% F.S. or less (At rated pressure range) 0.6 to 1 V ±7% F.S. or less (At set pressure range) Output impedance: Approx. 1 kΩ		None

Table 9. Output specifications

The cost of one of these switches is approximately 150 CND.

Relay

The relays are used in order to start the motors that we have selected running the arms. We need relays because it would be too hard for the PLC to start the motor without them. Therefore,

we have selected one relay, made by Omron, to run the motor in its normal state, and another to run it in its reverse state. The main requirements of this relay are to be able to start the motors we have selected while operating with 24 volts or less as well as have a operating current of 300 milliamperes or less.

Single- and Double-pole Relays

Rated voltage		Rated current		Coil resistance	Coil inductance (reference value)		Must operate voltage	Must release voltage	Max. voltage	Power consum. (approx.)
		50 Hz	60 Hz		Arm. OFF	Arm. ON	% of rated voltage			
AC	6 V	214.1 mA	183 mA	12.2 Ω	0.04 H	0.08 H	80% max.	30% min.	110%	1.0 to 1.2 VA (60 Hz)
	12 V	106.5 mA	91 mA	46 Ω	0.17 H	0.33 H				
	24 V	53.8 mA	46 mA	180 Ω	0.69 H	1.30 H				
	50 V	25.7 mA	22 mA	788 Ω	3.22 H	5.66 H				
	100/110 V	11.7/12.9 mA	10/11 mA	3,750 Ω	14.54 H	24.6 H				0.9 to 1 VA (60 Hz)
	110/120 V	9.9/10.8 mA	8.4/9.2 mA	4,430 Ω	19.20 H	32.1 H				
	200/220 V	6.2/6.8 mA	5.3/5.8 mA	12,950 Ω	54.75 H	94.07 H				
	220/240 V	4.8/5.3 mA	4.2/4.6 mA	18,790 Ω	83.50 H	136.40 H				
DC	6 V	150 mA		40 Ω	0.16 H	0.33 H		10% min.		0.9 W
	12 V	75 mA		160 Ω	0.73 H	1.37 H				
	24 V	36.9 mA		650 Ω	3.20 H	5.72 H				
	48 V	18.5 mA		2,600 Ω	10.6 H	21.0 H				
	100/110 V	9.1/10 mA		11,000 Ω	45.6 H	86.2 H				

Note: See notes on the bottom of next page.

Table 10. Coil ratings specifications for single and double pole relays

The relay series and model we decided to go with is the LY2 12VDC relay. As shown in Table 10, the requirements are achieved by the relay that we chose keeping the operating current and voltage equal to or below the required levels. The cost of these relays would be approximately 20 CND each, therefore 40 for two of them.

Motor

The motor will be used in our project to open and close the barrier, it is not possible to connect the motor with enough power directly from the output of the PLC, so the relay mentioned above is used for that purpose. So assuming that the motor will not connect direct to the PLC, the only requirement left is that the motor should be able to open and close the arm in a reasonable time. Due to the complexity of doing all the math to know the power required, we searched for other barriers to find which motor power is frequently used. Our conclusion was that ⅓ HP would suffice to open or close the arm in less than 3 seconds. Thus, the Century General Purpose 1725 RPM 115 Volts, Figure 6, met the requirements for this project.

Figure 6 - Century General Purpose 1725 RPM 115 Volts

All the product specification are shown in Table 11, the most relevant information is:

- ⅓ Hp
- 115 Volts
- 6.8 Amperes (Full Load)
- Presents reversible operation mode

BRAND	Century
MANUFACTURERS PART NUMBER	GF2034
HORSEPOWER	1/3
MOTOR RPM 60Hz	1725
VOLTAGE	115
PHASE	1
FRAME	48/56
ENCLOSURE TYPE	ODP
HERTZ	60
SPEEDS	1
ROTATION	Reversible
RATED RPM	1725
MOUNTING	Resilient
FULL LOAD AMPS	6.8
SHAFT DIAMETER	0.5
SHAFT LENGTH	5 4/9
BEARING TYPE	Sleeve
LENGTH LESS SHAFT INCHES	7-4/5
APPROVAL	UL and CSA
is_motor	Yes
MOTOR TYPE	Split Phase
HERTZ (HZ)	60

Table 11 - Motor Specification

The price for this motor is 117 CND.

Alarm

For this project the alarm will be used in two different situations:

- When the pressure switch detects that the arm is been forced up
- If the arm is closing and its sensor detects an object in its path

The requirements for the alarm are:

- Have the ability to connect with the PLC
- Operating voltage less or equal to 24 VDC
- Maximum current less or equal to 300 mA
- Be loud enough so people can hear it from a considerable distance

The alarm found, that met these requirements, is the Pollak Backup Alarm model PK41820, that can be seen in Figure 7.

Figure 7 - Alarm model PK41820

The specifications found in the datasheet for this component are listed below. Note that the most important information is in bold.

- **Single level...97dB(A) ± 4 @ 4'**
- **Multi-voltage -12-24 volts**
- Voltage spike protected
- Reverse polarity protected
- **Current draw less than 0.3 amps**
- Solid state electronics
- Certified conformance to S.A.E. J994, type C
- Meets State, Federal and U.S. Army Corps of Engineers' requirements
- Meets all European Standards for on and off-road vehicles (CE & E-Mark Certified)
- Size-4"Wx1.25"Dx2.5"H

- Mounting – four .5”Lx .25”W slots on 3.25" centers

The price for this component is 35 CND.

Power Supply

For this project, we will need a power supply that is able supply at least 24 VDC due to the operating voltage of the components used for the system. The power supply that meets this requirement is the power supply device that is used in the lab which is the VDRS-100-24 Power Supply as shown in Figure 8 below.

Figure 8 - VDRS-100-24 Power Supply

As shown in Table 11 below, the device is able to output 24 VDC which fits the requirement for this system. The price for this component is 126.20 CND.

MODEL	output voltage (Vdc)	output current max (A)	output power max (W)	ripple and noise[1] max (mVp-p)	efficiency (%)
VDRS-100-12	12	7.5	90	180	87
VDRS-100-15	15	6.4	96	180	87
VDRS-100-24	24	4	96	180	88
VDRS-100-48	48	2	96	250	87

Table 11 - VDRS-100-24 Power Supply Specification

IV. Implementation

State-based Design

The programming of the code will be implemented using a state-based diagram as shown in Figure 9 below. There are 5 states which are Idle, Normal (Opening), Reverse (Closing), Forced, and Interrupted State. With these states are 9 transitions. Idle State is the state where the motor and alarm are off. Normal (Opening) State is the state where the motor is on to raise the arm of the system and the alarm is off. Reverse (Closing) State is the state where the motor is on to lower the arm of the system and the alarm is off. The Forced and Interrupted States are states that are implemented to address the safety considerations as specified in this report. Forced State is the state where the alarm is on and the motor turns off. Interrupted State is the state where the alarm is on and the motor turns off. The following section will explain how the process is implemented and the details of the process of how each state is being transitioned from one state to another.

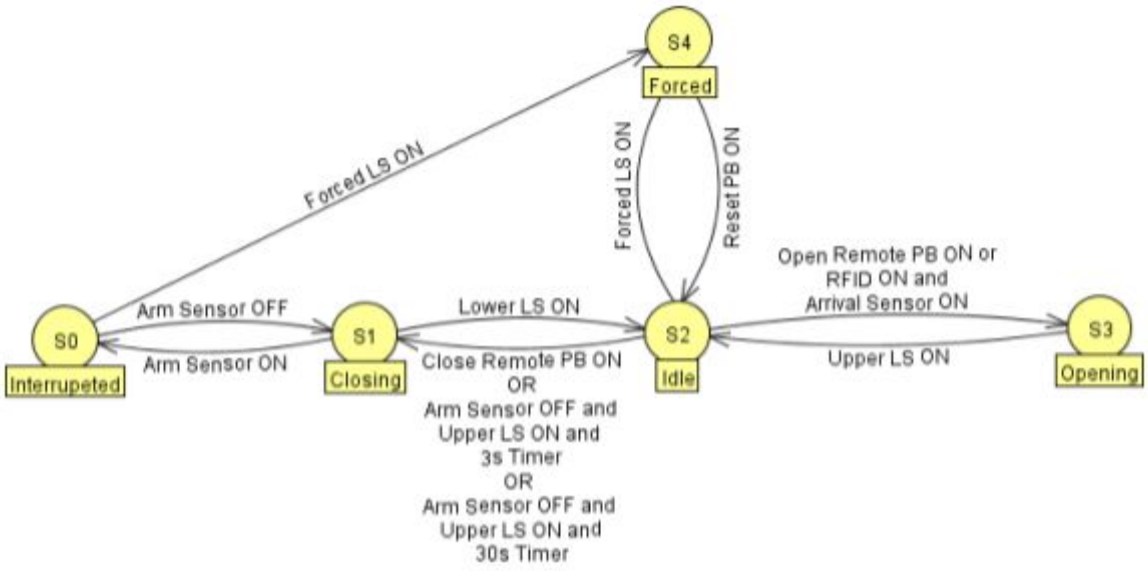


Figure 9 - State Diagram

System Process

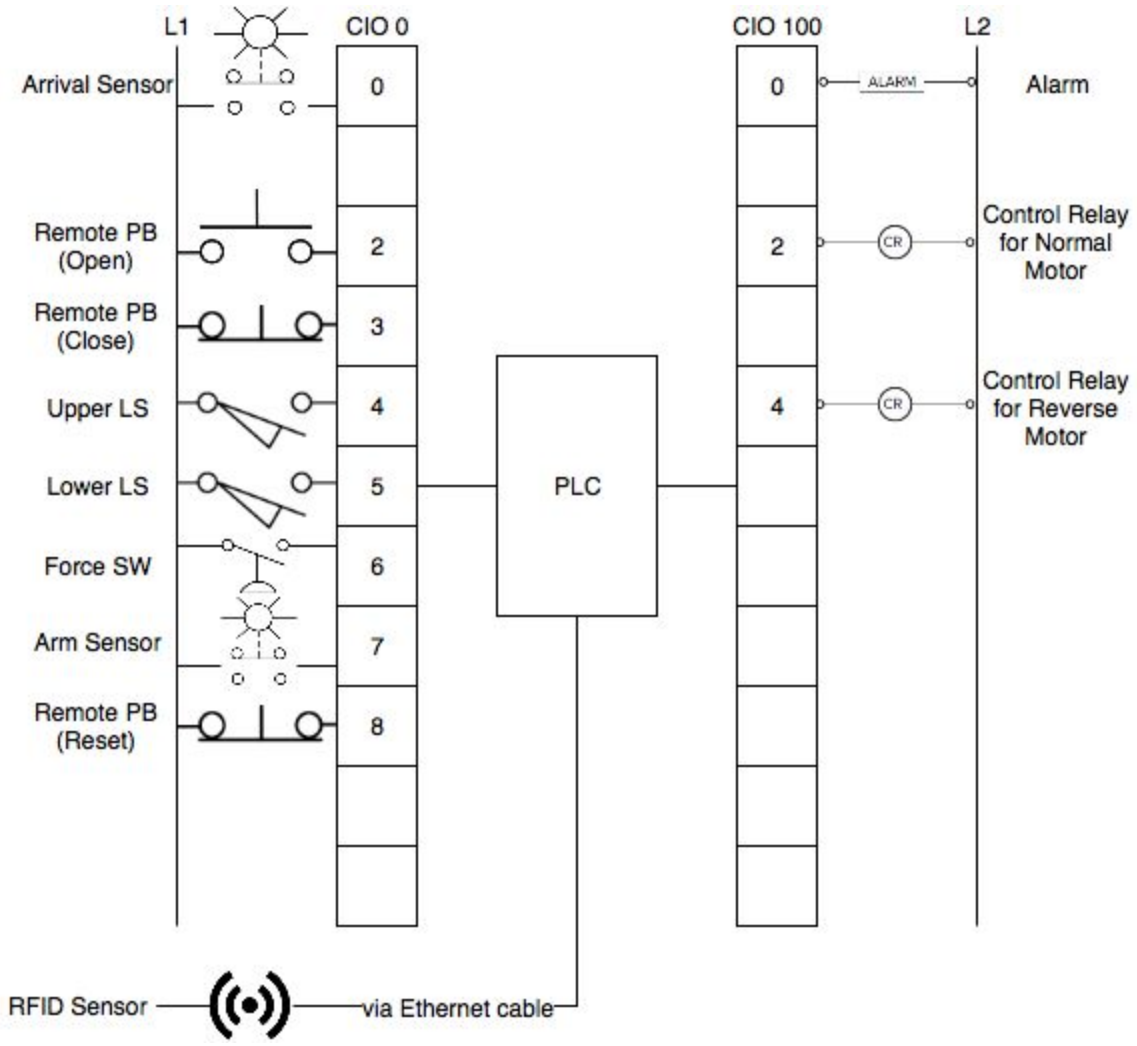
When the system starts, the system first goes to the Idle State. When a car approaches the parking barrier system, the arrival sensor will turn on and then the RFID sensor will scan the RF Tag present in the car which will take the value of the RF Tag to the PLC and then validate it. If

the RF Tag is valid, the system will move on to the Normal (Opening) State which will operate the motor. The motor will raise the arm until the upper limit switch is turned on then the system will return back to Idle State. In this case, this state allows the car to pass through. Once the car passes through the arm, the arm sensor will turn off which will then activate the three second timer so that after three seconds, the system will go to the Reverse (Closing) State which will operate the motor in reverse to lower the arm until the lower limit switch is on to go back to Idle State. In the situation that the car does not pass through the arm, the arm will go down after 30 seconds. There is also a remote push button that can allow the owner to manually operate the parking barrier system to open and close the arm as needed. In the situation when the arm is being forcibly opened, the force switch will activate which will make the system go to the Forced State. In this state, the alarm is turned on and in order to turn off the alarm and reset the system, a remote reset push button is required to be pressed to go back to Idle State. The alarm in the Forced State will turn on in intervals of every one second using a timer. In the situation during the Reverse (Closing) State where the car is still underneath the arm, the arm sensor will turn on which will make the system go to the Interrupted State. In this state, the alarm is turned on and it will remain on until the car passes through which will turn off the arm sensor and the system will return back to Reverse (Closing) State. The alarm in the Interrupted State will turn on in intervals of making noise every three seconds using a timer.

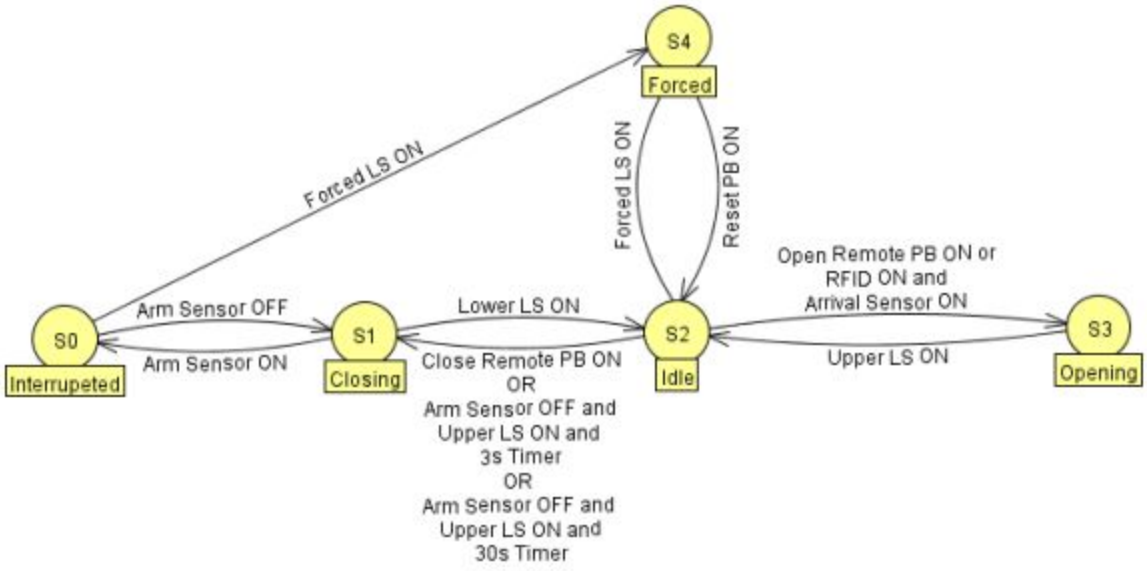
V. Appendices

Drawings/Diagrams

PLC Wiring Diagram



State Diagram



Data Sheets for selected equipment

Arrival Sensor and Arm Sensor (Through Beam Sensor) - https://cdn.automationdirect.com/static/specs/pe18mmc18.pdf

RFID (Radio-Frequency Identification) Sensor - https://industrial.omron.us/en/media/V680S_Datasheet_en_201501_Q75I-E-02_tcm849-114906.pdf

Remote Push button -https://industrial.omron.ca/en/media/A2W_Datasheet_A268-E1-01_tcm824-116840.pdf

Limit Switch - https://www.galco.com/buy/Cutler-Hammer-Div-of-Eaton-Corp/E47CMS30

Force Switch(Pressure Sensor) - https://content2.smcetech.com/pdf/ISE1.pdf

Relay - http://www.newark.com/omron-industrial-automation/ly2-12vdc/relay-dpdt-120vac-28vdc-15a/dp/42M2297

Motor - https://www.globalindustrial.com/p/motors/motors/specialty/a-o-smith-general-purpose-1725-rpm-115-volts-4

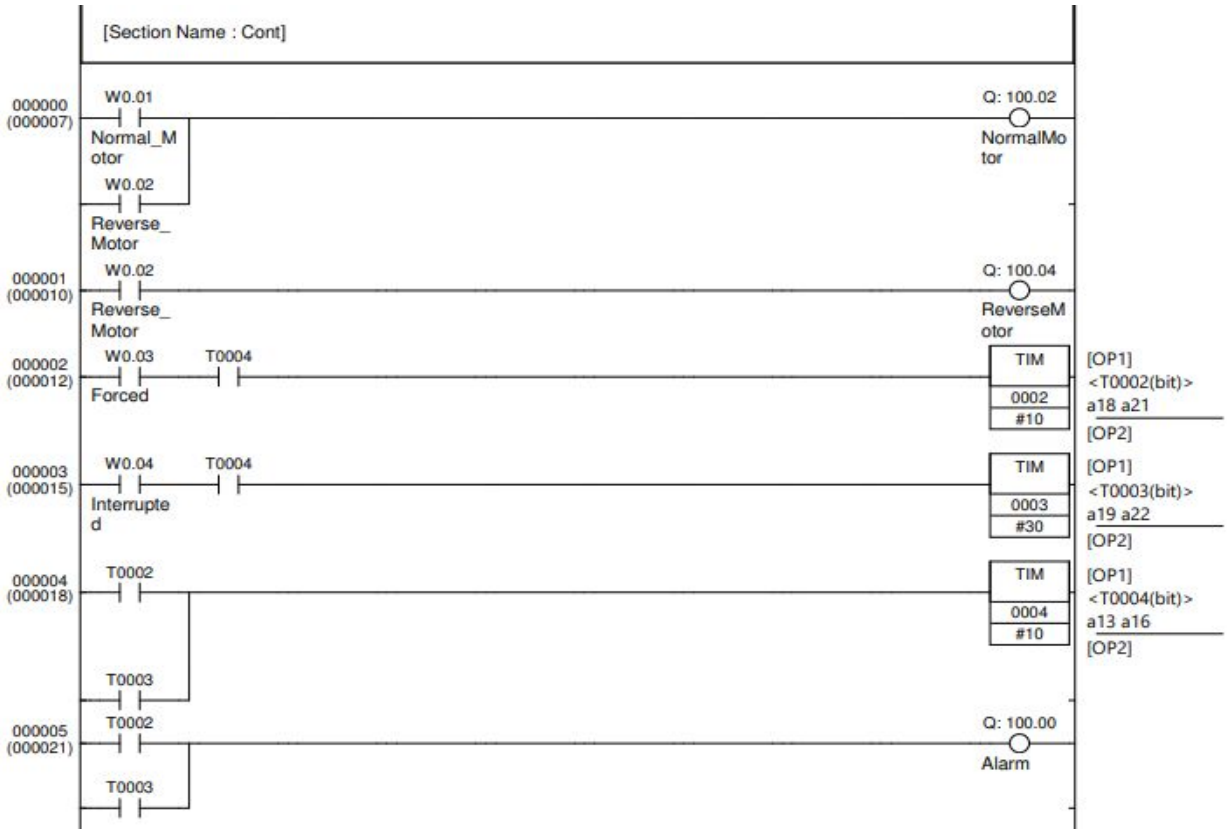
Alarm - https://www.powerandsignal.com/Images/New/Images/Pollak_Catalog.PDF

Power Supply - https://www.cui.com/product/resource/vdrs-100.pdf

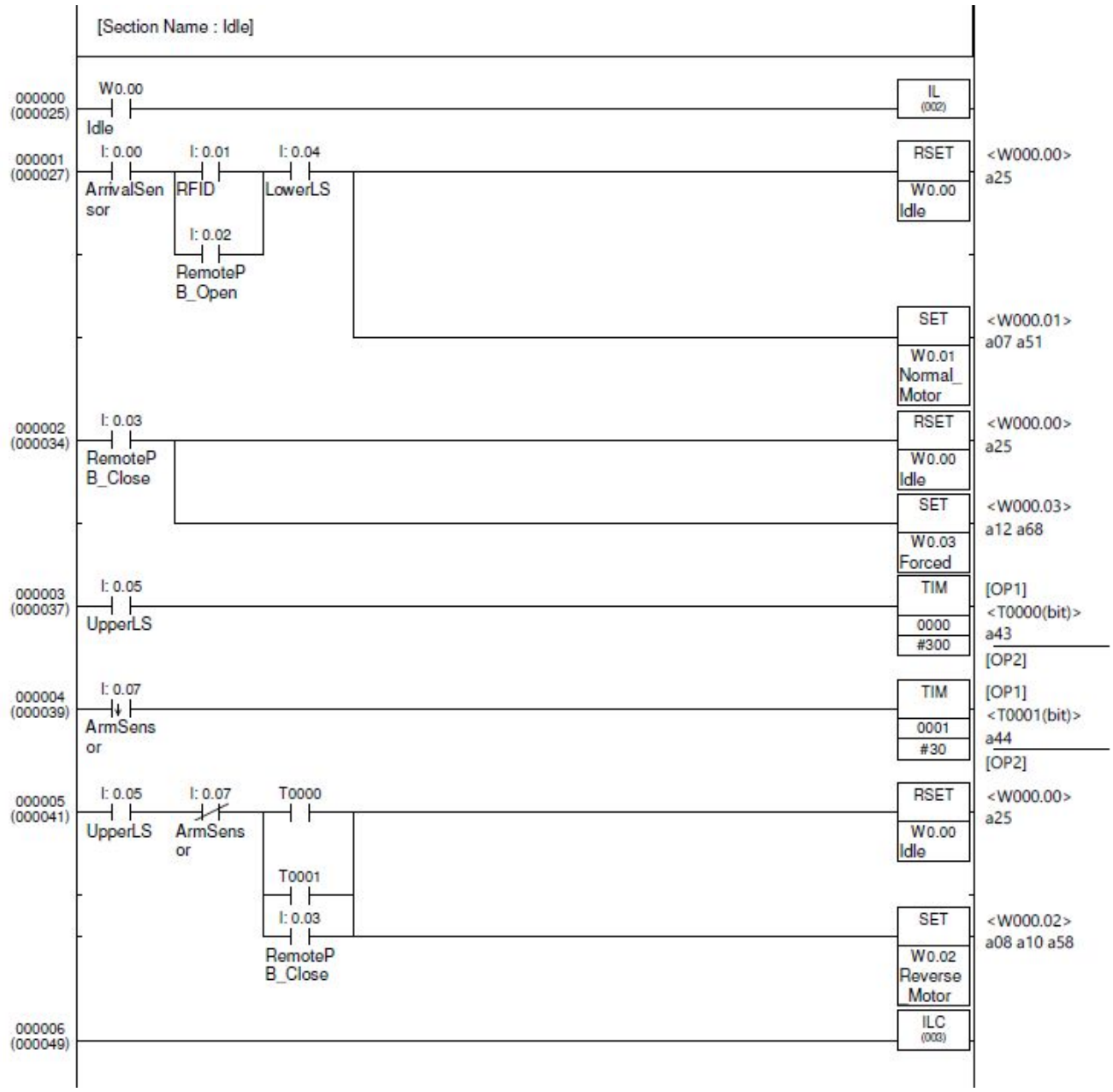
Ladder Logic Code

Initial Section

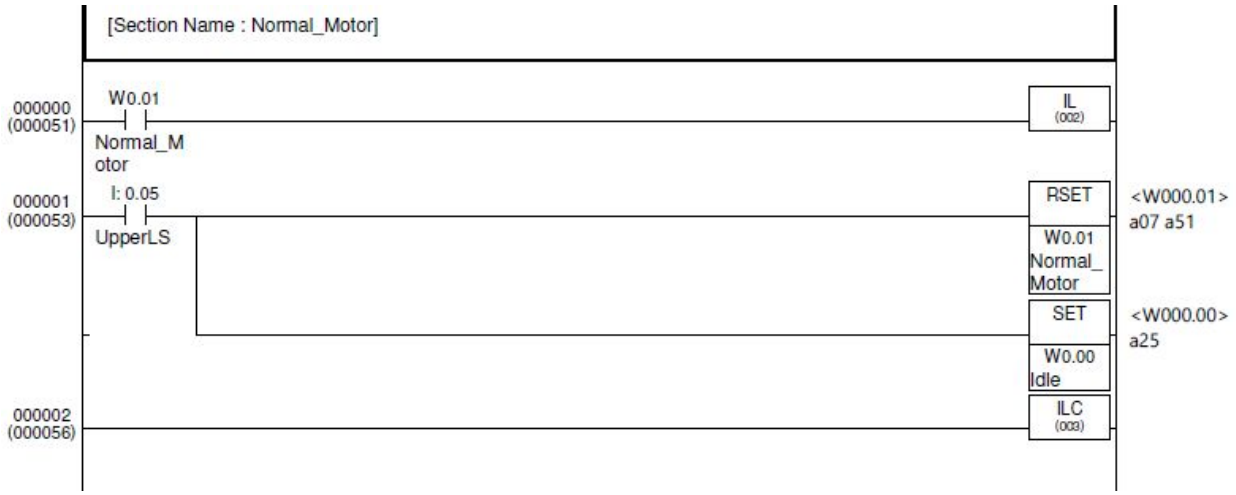
Continuous Section



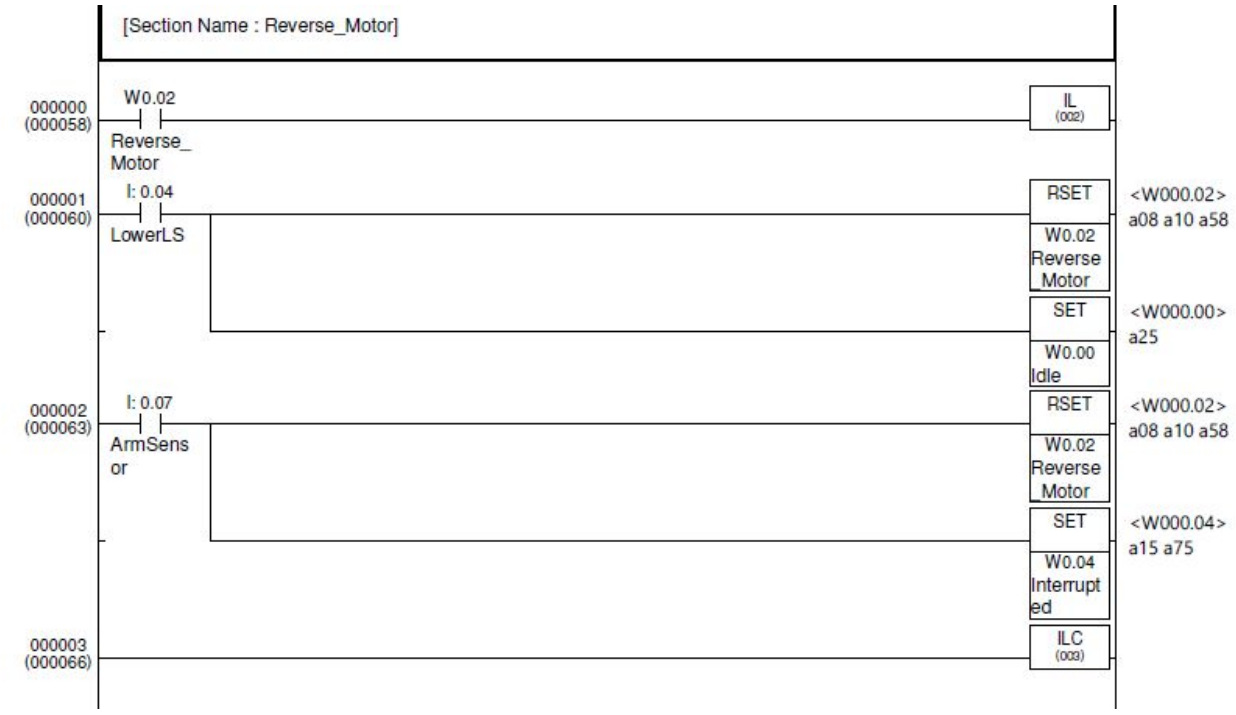
Idle State Section



Normal (Opening) State Section



Reverse (Closing) State Section



Forced State Section

Interrupted State Section