ECET 4530 – Industrial Motor Control **Sample Exam II – Old Version I – Problems**

Instructions: Show all of your work, making sure that your work in legible and that your reasoning can be followed. No credit will be given for illegible or illogical work. All final answers must be placed in the spaces provided and must be of the form specified in each problem statement. *This exam is closed book*.

REFER TO THE DIAGRAM SHOWN IN FIGURE A WHEN ANSWERING THE ALL OF THE PARTS OF "PROBLEM #2"

Problem #2) Assuming that the Ladder Diagram #1 shown in **Figure A** has been programmed into the Compact Logix PLC in the lab and the all of the required devices have been properly wired and energized, specify whether each of the following statements are true or false by **printing** either "**TRUE**" or "**FALSE**" in the blank answer space preceding each statement.

_____ Pressing only the "Start" button for the 1st time will immediately force at least one of the indicator lamps to illuminate.

_____ Assuming that the "Start" button has been pressed for the 1st time and that immediately afterwards "Button_A" is pressed and released, both the Green and the Yellow indicators will be illuminated.

_____ Assuming that the "Start" button has been pressed for the 1st time and that immediately afterwards "Button_B" is pressed and released, both the Red and the Blue indicators will be illuminated.

_____ Pressing the "Stop" button at any time will cause all illuminated indicator lamps to turn off immediately.

_____ Assuming that the "Start" button has been pressed for the 1st time and that immediately afterwards buttons "A" and "B" are both pressed and released, pressing and releasing "Button_C" will only force the Green Light to turn-off.

_____ Assuming that the "Start" button has been pressed for the 1st time and that immediately afterwards buttons "A" and "B" are both pressed and released, then only way to turn-off all illuminated indicators is to press/release the "Stop" button followed by "Button_C"

_____ The only way to keep the Yellow indicator illuminated after the "Start" button has been pressed is to press and hold-in "Button_A"

_____ Pressing and holding-in "Button_C" immediately after the "Start" button has been pressed will prevent buttons "A" and "B" from illuminating the Green and Red indicators if they were "off" when "Button_C" was initially pressed.

_____ Pressing and holding-in "Button_C" will have no effect on any illuminated indicators, although pressing and releasing "Button_C" has the potential to cause one illuminated indicators to turn-off

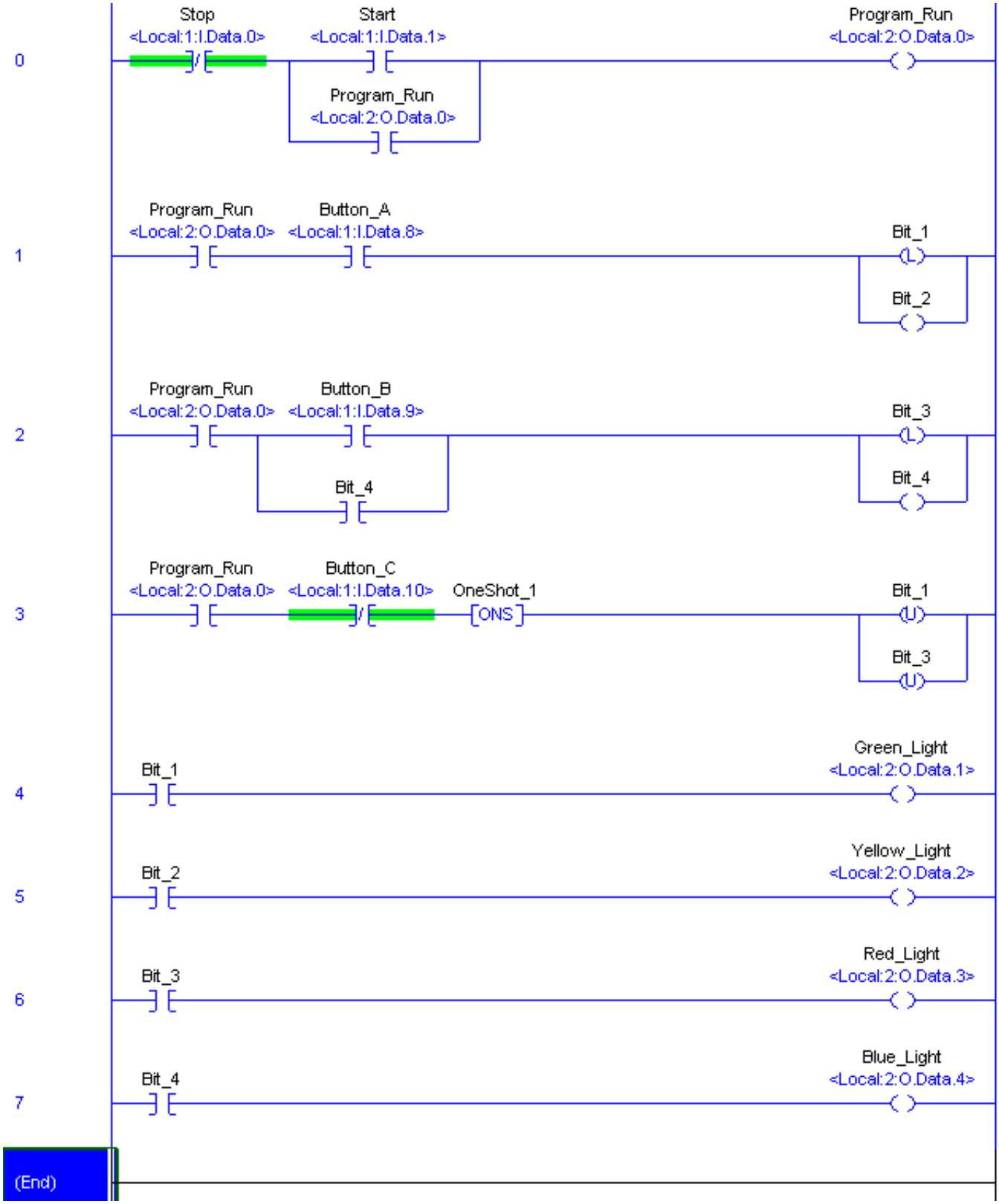


Figure A – Ladder Logic Diagram #1

REFER TO THE DIAGRAM SHOWN IN FIGURE B WHEN ANSWERING THE ALL OF THE PARTS OF "PROBLEM #3"

Problem #3) Assuming that the Ladder Diagram #2 shown in **Figure B** has been programmed into the Compact Logix PLC in the lab and the all of the required devices have been properly wired and energized, describe in detail the exact sequence of events that will occur when the "Start" button is pressed for the first time in terms of the operation of the Green, Yellow, and Red indicators. Be specific and include time references for when the lights go "on" and/or "off".

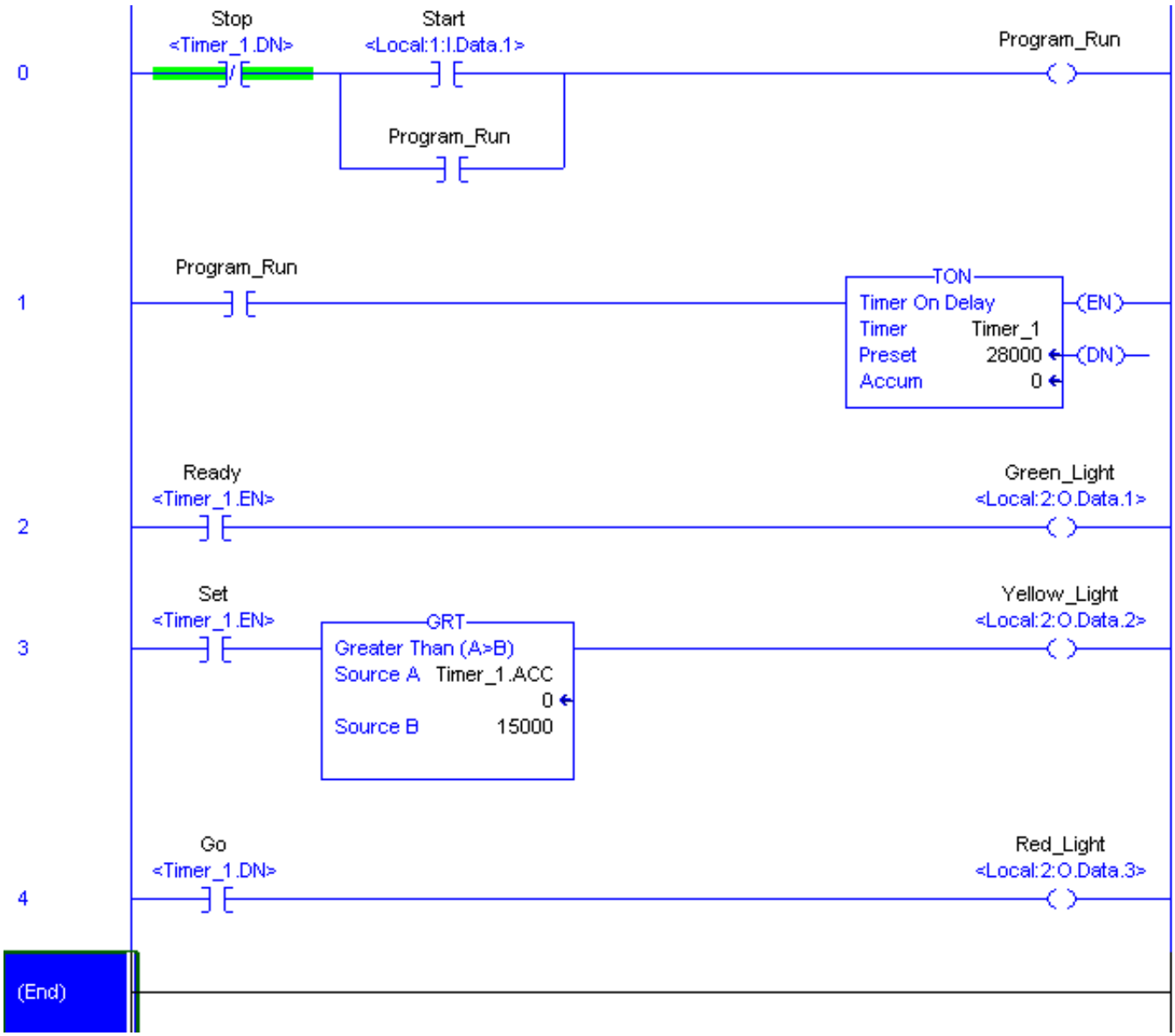
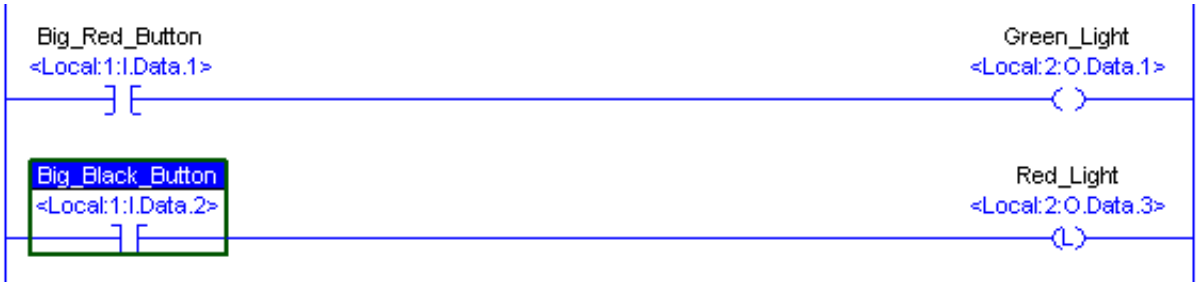


Figure B – Ladder Logic Diagram #2

Problem #4) Given the two rungs from a ladder diagram shown immediately below this problem statement, briefly describe any similarities and/or differences in operation between the two rungs.
(I.e. – does the "Big_Red_Button" affect the Green light in the same manner that the "Big_Black_Button" affects the Red light?**)**



Problem #5) Specify whether each statement is TRUE or FALSE **by PRINTING TRUE or FALSE in the blank** preceding the statement. ***Do NOT write only "T" or "F" in the blanks*.**

_____ Using the VFD:O.Reverse —(L)— instruction will guarantee that the Variable Speed Drive (VFD) to continuously rotate its motor load in the reverse direction provided that the instruction properly sets the "reverse" bit and that the bit is not unlatched.

_____ The VFD:O.AccelRate1 —( )— instruction is used to instruct the PowerFlex40 VFD which of the two acceleration rates previously programmed into the VFD should be used when increasing the output frequency of the drive.

_____ Although the VFD can be configured to receive a "start" command from **either** its front panel or the VFD:O.Start —(L)— instruction, the VFD will always accept a "stop" command from any source.

_____ The VFD:O.ClearFaults —( )— used to clear a fault and restart the VFD after is has shut-down after to the occurrence of a fault.

ECET 4530 – Industrial Motor Control **Sample Exam II – Old Version I – Solutions**

Instructions: Show all of your work, making sure that your work in legible and that your reasoning can be followed. No credit will be given for illegible or illogical work. All final answers must be placed in the spaces provided and must be of the form specified in each problem statement. *This exam is closed book*.

REFER TO THE DIAGRAM SHOWN IN FIGURE A WHEN ANSWERING ALL OF THE PARTS OF "PROBLEM #2"

Problem #2) Assuming that the Ladder Diagram #1 shown in **Figure A** has been programmed into the Compact Logix PLC in the lab and the all of the required devices have been properly wired and energized, specify whether each of the following statements are true or false by **printing** either "**TRUE**" or "**FALSE**" in the blank answer space preceding each statement.

___False___ Pressing only the "Start" button for the 1st time will immediately force at least one of the indicator lamps to illuminate.

Button_A or Button_B must also be pressed to turn on any lights

___False___ Assuming that the "Start" button has been pressed for the 1st time and that immediately afterwards "Button_A" is pressed and released; both the Green and the Yellow indicators will be illuminated.

Only the Green is "latched" on, the Yellow will turn off if A is released

___True___ Assuming that the "Start" button has been pressed for the 1st time and that immediately afterwards "Button_B" is pressed and released; both the Red and the Blue indicators will be illuminated.

___False___ Pressing the "Stop" button at any time will cause all illuminated indicator lamps to turn off immediately.

Green and Red are "latched" on, they need to be "unlatched" to go off

___True___ Assuming that the "Start" button has been pressed for the 1st time and that immediately afterwards buttons "A" and "B" are both pressed and released, pressing and releasing "Button_C" will only force the Green Light to turn-off.

___False___ Assuming that the "Start" button has been pressed for the 1st time and that immediately afterwards buttons "A" and "B" are both pressed and released, then only way to turn-off all illuminated indicators is to press/release the "Stop" button followed by "Button_C"

Once "Program_Run" is deactivated by "Stop", "Button_C" will have no effect.

___True___ The only way to keep the Yellow indicator illuminated after the "Start" button has been pressed is to press and hold-in "Button_A"

___False___ Pressing and holding-in "Button_C" immediately after the "Start" button has been pressed will prevent buttons "A" and "B" from illuminating the Green and Red indicators if they were "off" when "Button_C" was initially pressed.

Pressing and holding C has <u>no</u> effect. C only triggers the one-shot if released

___True___ Pressing and holding-in "Button_C" will have no effect on any illuminated indicators, although pressing and releasing "Button_C" has the potential to cause one illuminated indicator to turn-off

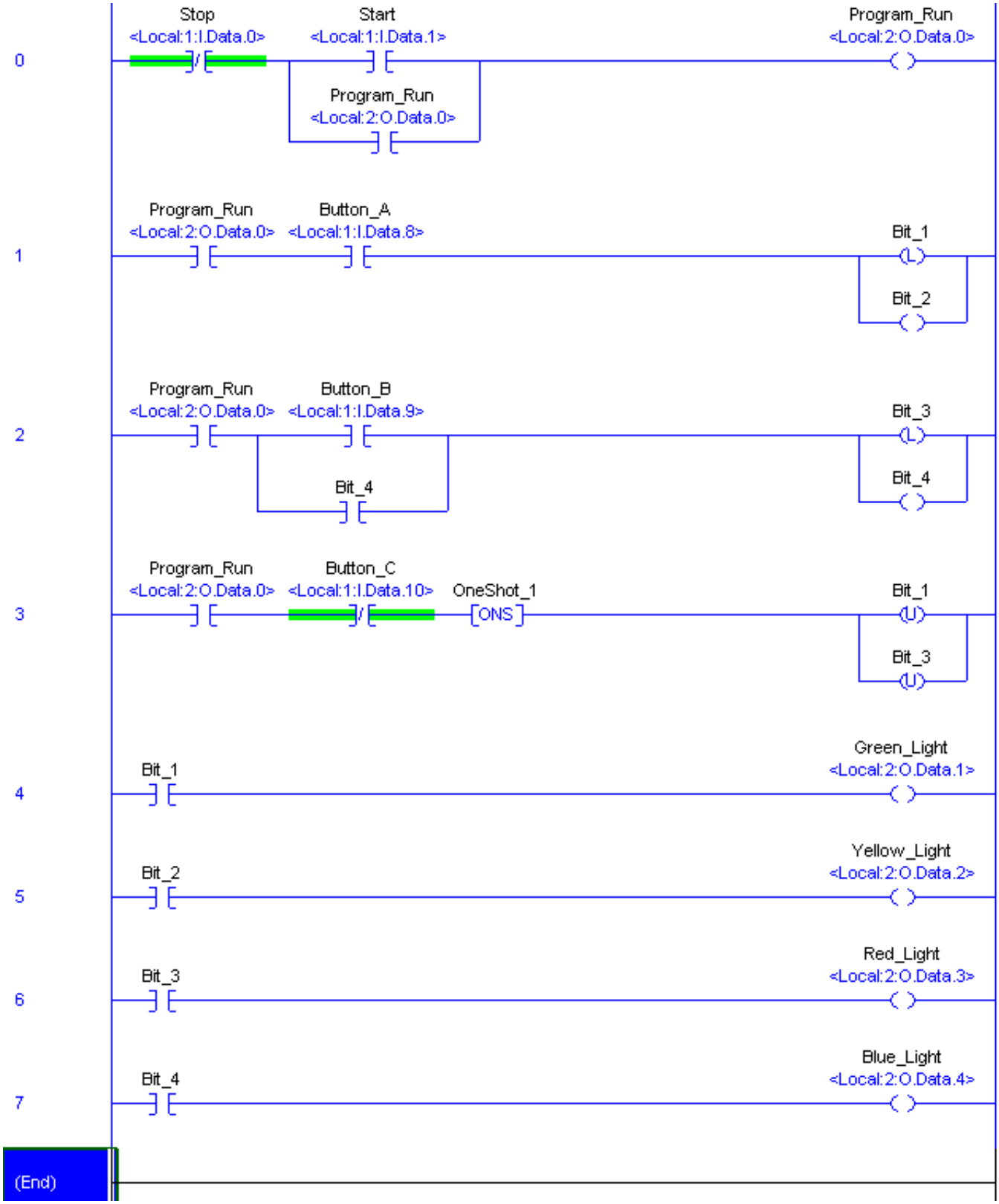


Figure A – Ladder Logic Diagram #1

REFER TO THE DIAGRAM SHOWN IN FIGURE B WHEN ANSWERING THE ALL OF THE PARTS OF "PROBLEM #3"

Problem #3) Assuming that the Ladder Diagram #2 shown in **Figure B** has been programmed into the Compact Logix PLC in the lab and the all of the required devices have been properly wired and energized, describe in detail the exact sequence of events that will occur when the "Start" button is pressed for the first time in terms of the operation of the Green, Yellow, and Red indicators. Be specific and include time references for when the lights go "on" and/or "off".

ANSWER

Start Pressed:	**Timer begins counting from time=0**	**Timer_1.EN➡1**	**Green On**
	Timer reaches t=15000	**Accum>15000**	**Yellow On**
	Timer reaches t=28000	**Timer_1.DN➡1**	**~~Red On~~**

But when Timer_1.DN➡1, the "Stop" XIO aliased to Timer_1.DN will be FALSE, causing the "Program_Run" OTE become FALSE, in turn disabling Timer_1 and causing the OTEs for <u>all lights</u> to become FALSE (All lights turn OFF)
(This will happen so quickly that the Red light will never actually illuminate)

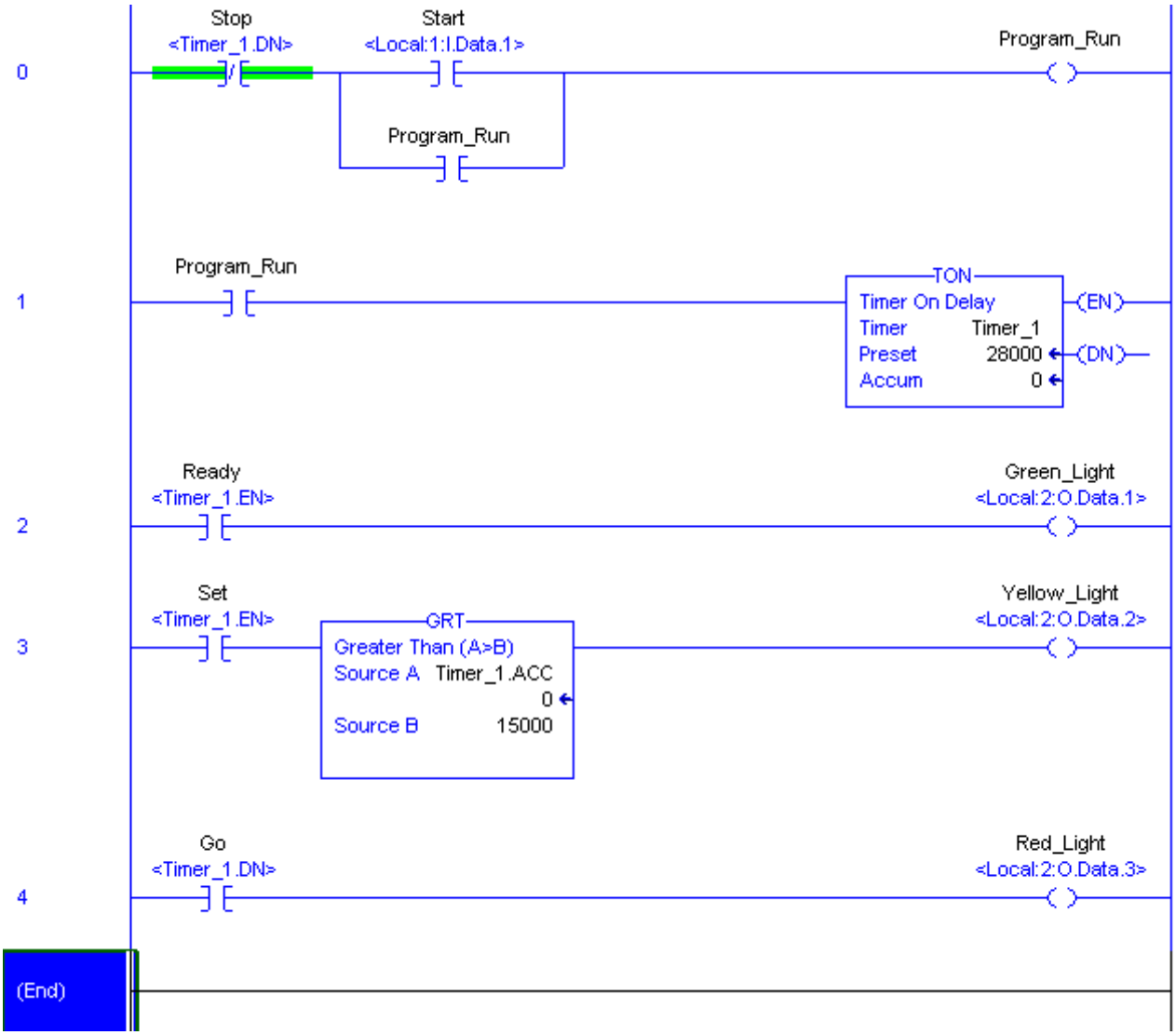
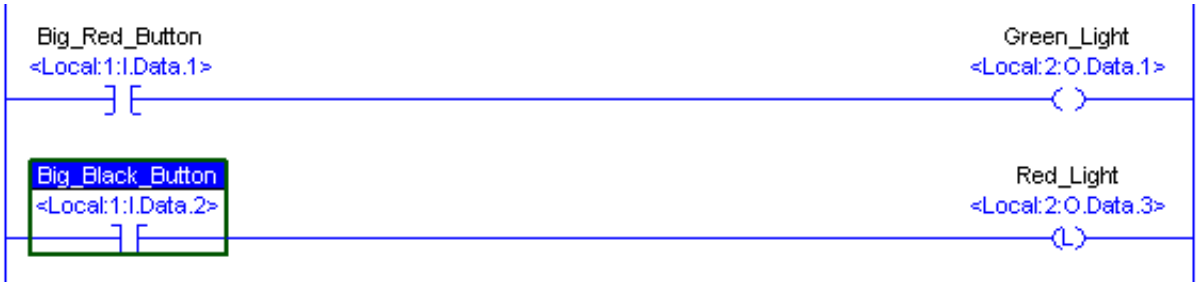


Figure B – Ladder Logic Diagram #2

Problem #4) Given the two rungs from a ladder diagram shown immediately below this problem statement, briefly describe any similarities and/or differences in operation between the two rungs.
(I.e. – does the "Big_Red_Button" affect the Green light in the same manner that the "Big_Black_Button" affects the Red light?**)**



ANSWER

When the Big_Red_Button is pressed, the Green light will turn on and it will stay on as long as the button is held. If the button is released, the light will turn off.

When the Big_Black_Button is pressed, the Red light will turn on and it will stay on, even if the button is released, because the output device was "latched" on. It will only go off if an "unlatch" command is activated.

Problem #5) Specify whether each statement is True or False **by PRINTING True or False in the blank** preceding the statement. ***Do NOT write only "T" or "F" in the blanks*.**

False Using the VFD:O.Reverse —(L)— instruction will guarantee that the Variable Speed Drive (VFD) to continuously rotate its motor load in the reverse direction provided that the instruction properly sets the "reverse" bit and that the bit is not unlatched.

Need to Unlatch the Forward bit to guarantee the Reverse Direction.

True The VFD:O.AccelRate1 —( )— instruction is used to instruct the PowerFlex40 VFD which of the two acceleration rates previously programmed into the VFD should be used when increasing the output frequency of the drive.

True Although the VFD can be configured to receive a "start" command from **either** its front panel or the VFD:O.Start —(L)— instruction, the VFD will always accept a "stop" command from any source.

False The VFD:O.ClearFaults —( )— used to clear a fault and restart the VFD after is has shut-down after to the occurrence of a fault.

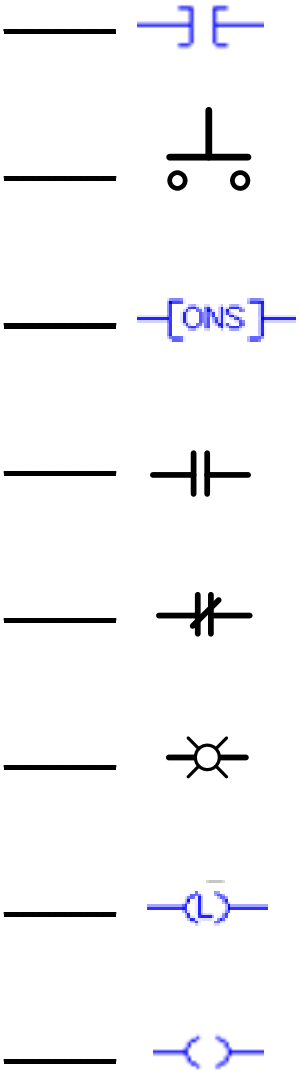
It clears a fault, but does not specifically "restart" the VFD.

ECET 4530 – Industrial Motor Control **Sample Exam II – Old Version II – Problems**

Instructions: Show all of your work, making sure that your work in legible and that your reasoning can be followed. No credit will be given for illegible or illogical work. All final answers must be placed in the spaces provided and must be of the form specified in each problem statement. *This exam is closed book*.

Note – unless otherwise specified within each problem statement, assume that if a push-button is pressed, it is held-in for less than ½-second and then released. Furthermore, if a button is pressed, it will be released before any additional buttons are pressed.

Problem #1) Match the symbols shown in the left-hand column with the devices listed in the right-hand column by writing the letter associated with the correct device next to the appropriate symbol. Note that both standard NEMA symbols and Compact Logix ladder diagram device symbols are shown in the first column.



A) Contactor's Field Coil

B) OTE (Output Energize)

C) Circuit Breaker

D) Single-Pole Switch in Off Position

E) Control Relay's Field Coil

F) Indicator Lamp

G) XIO (Examine if Opened)

H) XIC (Examine if Closed)

I) ONS (On Switch)

J) ONS (One Shot)

K) OTL (Output Latch)

L) OTU (Output Unlatch)

M) Normally Open Pushbutton

N) Normally Closed Pushbutton

O) Normally Open Contact

P) Normally Closed Contact

Q) Pressure Switch

R) None of the above

Problem #2) Figure-P2 shows both the ladder-logic program downloaded into a PLC and the wiring diagram of the motor-control system that the PLC is controlling in the Q-215 laboratory.

You may assume that the PLC is properly supplied with AC power, that it is properly connected to the control system's Ethernet network, and that the key-switch on the front panel of the PLC has been switched to "Run" mode.

If the system is operating properly:

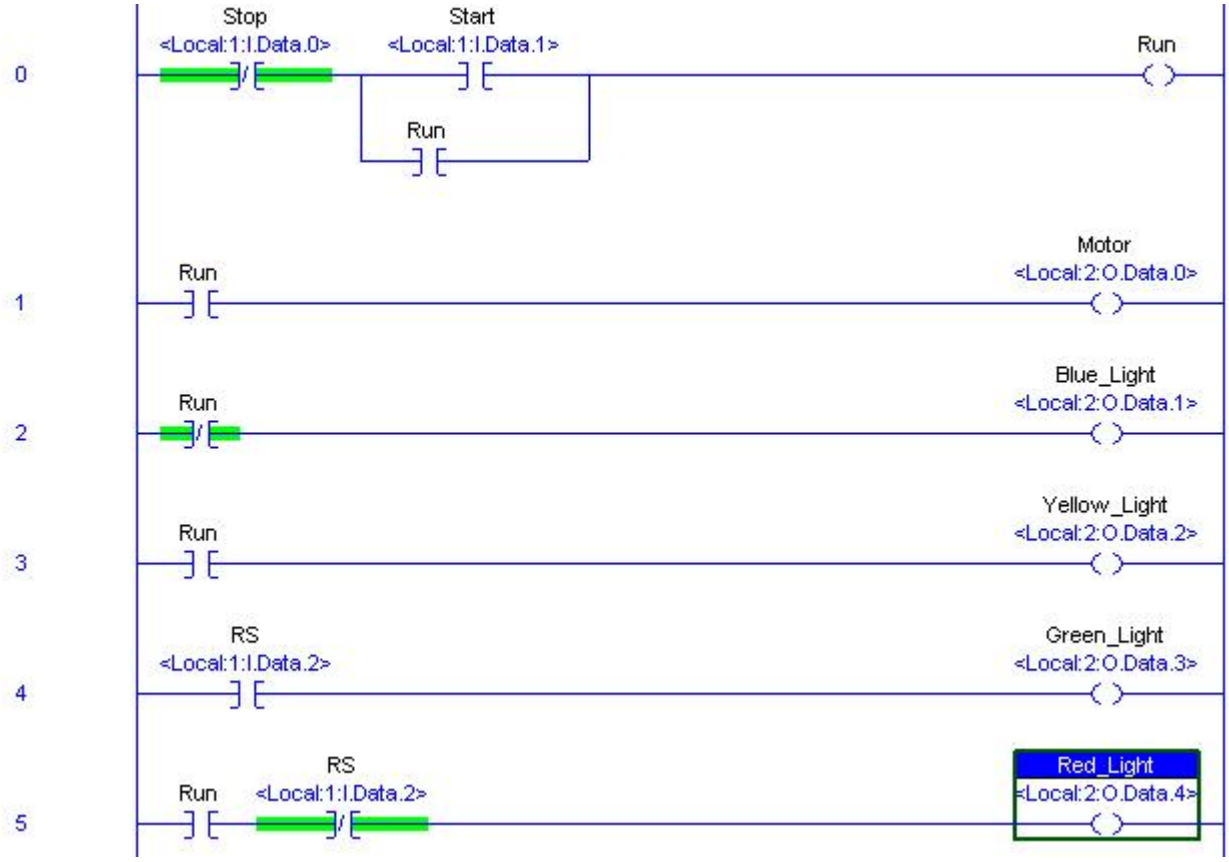
a) Determine which lights will be illuminated (on) and which lights will be off if the "**Start**" button is pressed and released.

Blue _____ Yellow _____ Green _____ Red _____
(Write either "on" or "off" in each of the above blanks to specify the status of each light)

b) Determine which lights will be illuminated (on) and which lights will be off if the "**Stop**" button is pressed and released <u>after</u> the "Start" button is pressed and released.

Blue _____ Yellow _____ Green _____ Red _____
(Write either "on" or "off" in each of the above blanks to specify the status of each light)

Describe the <u>function</u> (purpose) of the **Red** light in the space below:
(I.e. – if the system operator sees that the Red light is illuminated (on), what information does this provide about the operational state of the system?)



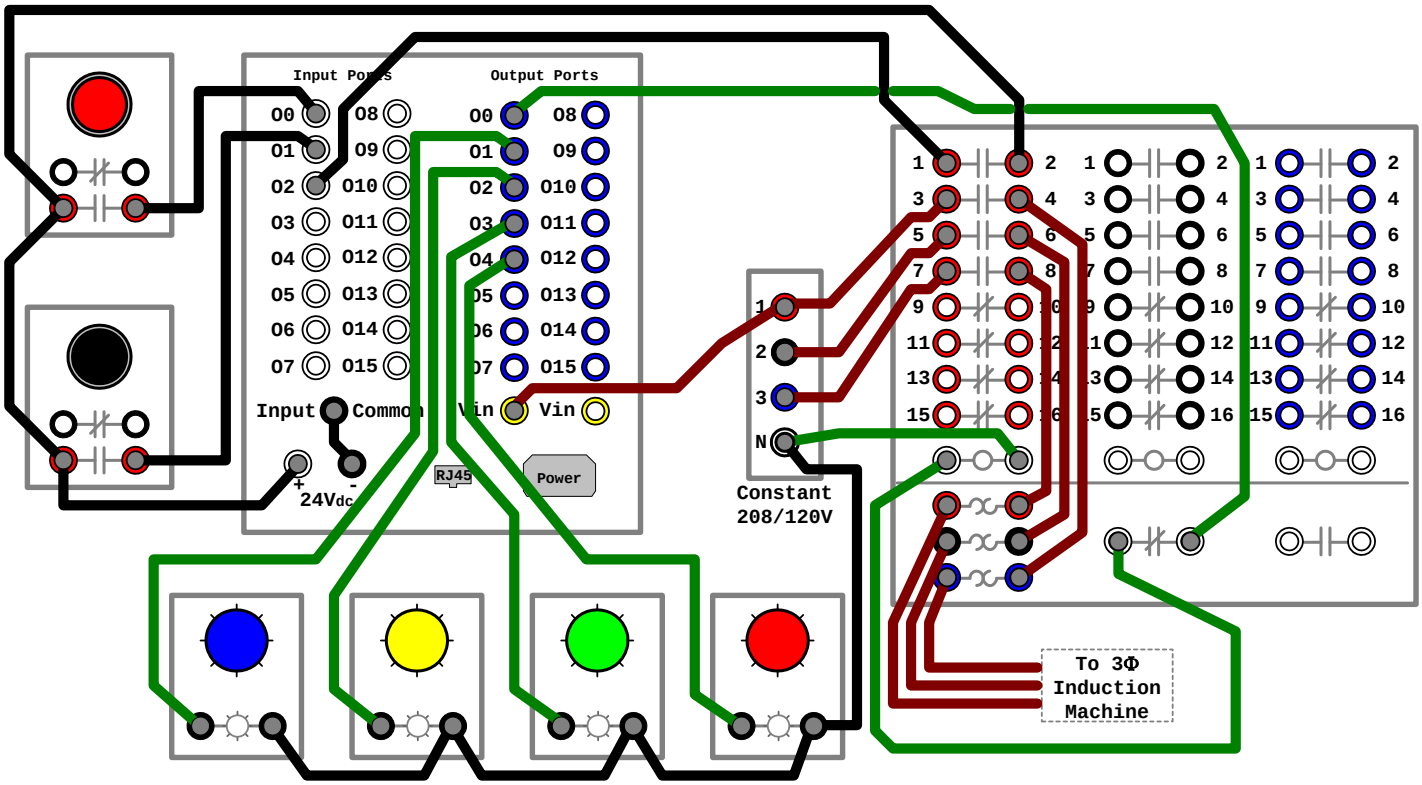


Figure P2 – Ladder Diagram and Wiring Diagram for Problem #2

Problem #3) Figure-P3 shows the ladder-logic program downloaded into a PLC.

The PLC has two normally-open pushbuttons (Start and Stop) wired to its first two inputs that supply a $+24V_{DC}$ signal to the inputs when pressed.

The PLC also has four colored lights (blue, yellow, green and red) wired to its first four outputs that are illuminated when the outputs are energized.

You may assume that the PLC is functioning properly.

If the "Start" button is pressed at 1:00pm:

a) Beginning at 1:00pm, specify the sequence of operational events (lights turning on and off) that will occur if no other buttons are pressed after the "Start" button is pressed.

Time	Event (Light ON or OFF)
1:00pm	

b) Beginning at 1:00pm, specify the sequence of operational events (lights turning on and off) that will occur if the "End" button is pressed at 1:03pm.

Time	Event (Light ON or OFF)
1:00pm	

c) Beginning at 1:00pm, specify the sequence of operational events (lights turning on and off) that will occur if the “End” button is pressed at 1:10pm.

Time	Event (Light ON or OFF)
1:00pm	

d) Beginning at 1:00pm, specify the sequence of operational events (lights turning on and off) that will occur if the “End” button is pressed at 1:20pm.

Time	Event (Light ON or OFF)
1:00pm	

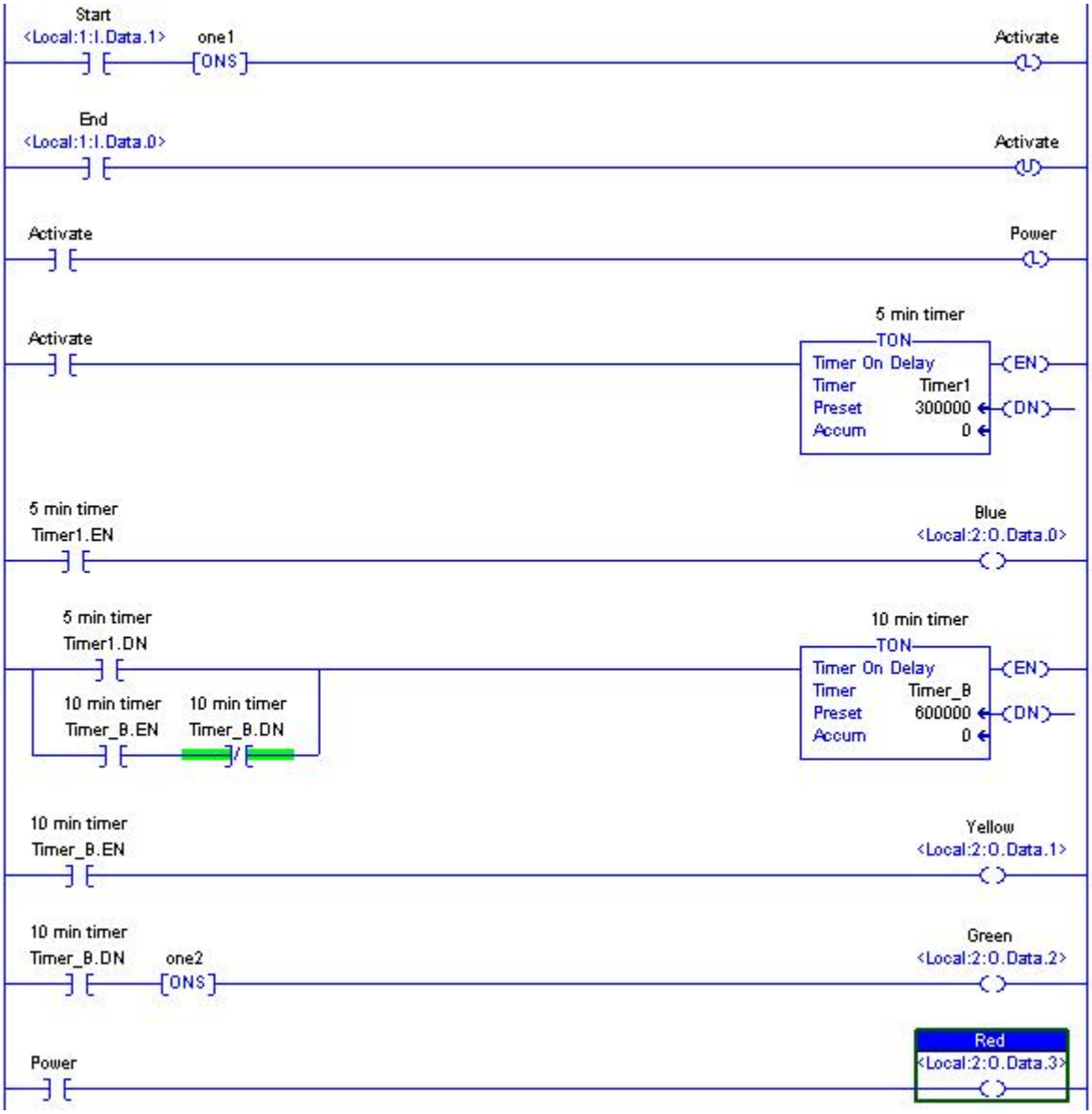


Figure P3 – Ladder Diagram and Wiring Diagram for Problem #3

Problem #4) Specify whether each of the following statements are true or false by **printing** either "**TRUE**" or "**FALSE**" in the blank answer space preceding each statement.

_____ Although the VFD can be configured to receive a "start" command **either** from the green button on its front panel or from the PLC by means of the VFD:O.Start instruction, the VFD will always accept a "stop" command from both sources.

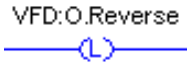
_____ The instruction <Timer_1.DN> will activate (conduct) when the value stored in the Accumulator of Timer_1 reaches the timer's Preset value, and it will remain active from that point on as long as the timer remains Enabled.

_____ An Overload Relay operates on a time-curve during start-up to avoid shutting-down the motor due to the large currents that it normally draws during "start-up", but then it responds instantaneously to overloads once the motor is fully operational.

_____ Although contactors are designed to be able to disconnect an energized motor from its supply lines (i.e. – shut-down the motor) even during overload conditions, contactor's are not designed to interrupt short-circuit or other similarly large currents.

_____ A Normally Closed (NC) Auxiliary Contact is often used to “hold-in” a contactor after the “start” pushbutton in a motor control system is pressed and then released.

_____ A “series-resistance” motor starter requires two contactors that are energized simultaneously when starting an induction motor.

_____ When using the 

instruction to reverse the direction of the VFD, the “Forward” bit within the VFD’s memory will automatically be unlatched.

_____ When entering a ladder diagram into the RSLogix5000 software, a column of **e**’s will appear to the left of the rung to signify that there has been an error in the configuration of one of the instructions contained on the rung.

_____ BOOTP is a software process that runs on the PLC and is used to assign an IP address to the computer used to program the PLC across the Ethernet network..

_____ An “alias-type” tag is a tag that refers to either a previously-defined alias-type or base-type tag that has a different name tag-name.

_____ Although removing power from the VFD will cause it to lose its IP Address, the PLC is able to retain its IP Address when power is removed from the device as currently configured in the Q-215 lab.

_____ The MOV command is used to copy data from one memory location to another (possibly remote) memory location.

_____ Sending a frequency value of 30Hz to the **VFD:O.FreqCommand** memory location within the VFD will immediately cause the drive vary its output frequency such that it is supplying its motor-load with a 30Hz set of AC waveforms.

_____ The MAC Address of a device on an Ethernet network is the unique physical address that is permanently assigned to the device.

_____ When an operational VFD is instructed to reverse the direction of its motor-load, the VFD will first lower the frequency of its output voltages to zero in order to stop the motor, after which it will re-accelerate the motor in the reverse direction by supplying the motor with a negative-sequence set of three-phase voltage waveforms.

ECET 4530 – Industrial Motor Control **Sample Exam II – Old Version II – Solutions**

Instructions: Show all of your work, making sure that your work in legible and that your reasoning can be followed. No credit will be given for illegible or illogical work. All final answers must be placed in the spaces provided and must be of the form specified in each problem statement. *This exam is closed book*.

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Problem #1) Match the symbols shown in the left-hand column with the devices listed in the right-hand column by writing the letter associated with the correct device next to the appropriate symbol. Note that both standard NEMA symbols and Compact Logix ladder diagram device symbols are shown in the first column.

H 

M 

J 

O 

P 

F 

K 

B 

A) Contactor's Field Coil

B) OTE (Output Energize)

C) Circuit Breaker

D) Single-Pole Switch in Off Position

E) Control Relay's Field Coil

F) Indicator Lamp

G) XIO (Examine if Opened)

H) XIC (Examine if Closed)

I) ONS (On Switch)

J) ONS (One Shot)

K) OTL (Output Latch)

L) OTU (Output Unlatch)

M) Normally Open Pushbutton

N) Normally Closed Pushbutton

O) Normally Open Contact

P) Normally Closed Contact

Q) Pressure Switch

R) None of the above

Problem #2) Figure-P2 shows both the ladder-logic program downloaded into a PLC and the wiring diagram of the motor-control system that the PLC is controlling in the Q-215 laboratory.

You may assume that the PLC is properly supplied with AC power, that it is properly connected to the control system's Ethernet network, and that the key-switch on the front panel of the PLC has been switched to "Run" mode.

If the system is operating properly:

a) Determine which lights will be illuminated (on) and which lights will be off if the "**Start**" button is pressed and released.

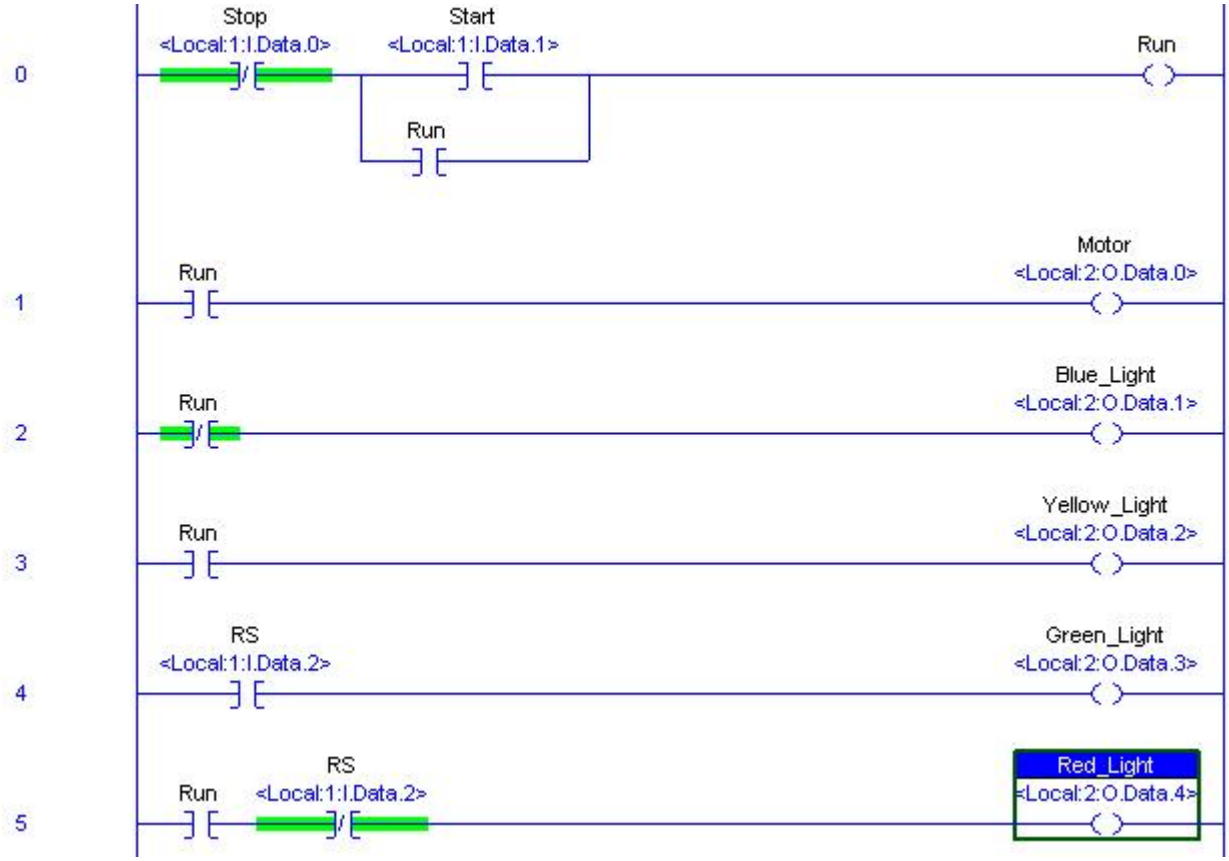
Blue ___Off___ Yellow ___ON___ Green ___ON___ Red ___Off___

b) Determine which lights will be illuminated (on) and which lights will be off if the "**Stop**" button is pressed and released after the "Start" button is pressed and released.

Blue ___ON___ Yellow ___Off___ Green ___Off___ Red ___Off___

Describe the function (purpose) of the **Red** light in the space below:
(I.e. – if the system operator sees that the Red light is illuminated (on), what information does this provide about the operational state of the system?)

Input-2 of the PLC is connected to a NO auxiliary contact of the contactor. Thus, if the contactor is actuated to supply power to the motor, Input-2 will go high and the Green lamp will be On. If the Red lamp is illuminated while "Run" is still active, then the contactor has unexpectedly dropped-out. This most likely indicates that the OL Relay tripped due to a motor overload, in-turn de-energizing the field coil of the mail contactor and causing the contactor to drop-out.



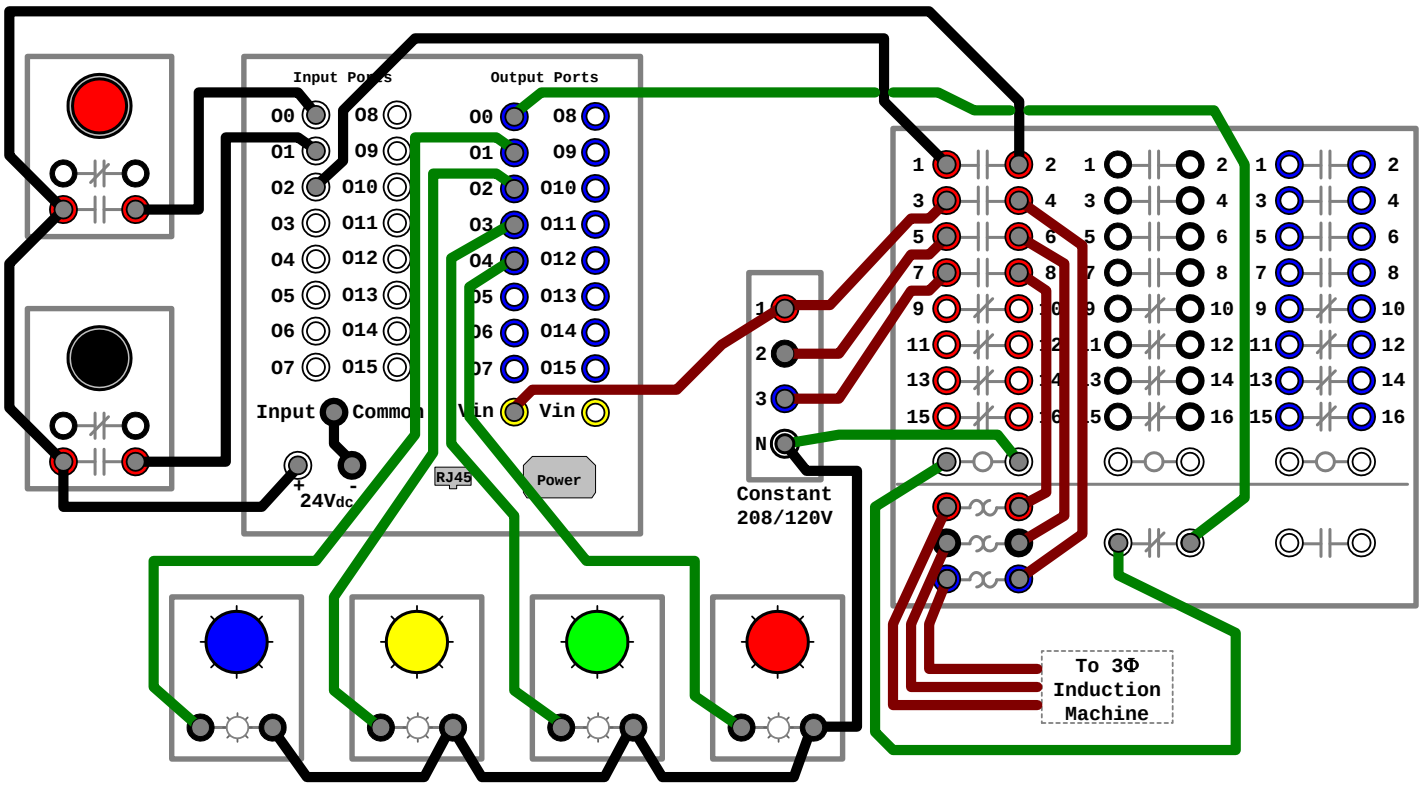


Figure P2 – Ladder Diagram and Wiring Diagram for Problem #2

Problem #3) Figure-P3 shows the ladder-logic program downloaded into a PLC.

The PLC has two normally-open pushbuttons (Start and Stop) wired to its first two inputs that supply a +24V_{DC} signal to the inputs when pressed.

The PLC also has four colored lights (blue, yellow, green and red) wired to its first four outputs that are illuminated when the outputs are energized.

You may assume that the PLC is functioning properly.

IF THE "**START**" BUTTON IS PRESSED AT **1:00PM**:

a) Beginning at 1:00pm, specify the sequence of operational events (lights turning on and off) that will occur if no other buttons are pressed after the "Start" button is pressed.

Time	Event (Light ON or OFF)
1:00pm	**Red** and **Blue** both turn on
1:05pm	**Yellow** turns on
1:15pm	**Green** turns on but immediately turns back off due to ONS.
No further changes occur as long as no buttons are pushed	

b) Beginning at 1:00pm, specify the sequence of operational events (lights turning on and off) that will occur if the "**End**" button is pressed at **1:03pm**.

Time	Event (Light ON or OFF)
1:00pm	**Red** and **Blue** both turn on
1:03pm	**Blue** turn off (Red stays on)
No further changes occur as long as no buttons are pushed	

c) Beginning at 1:00pm, specify the sequence of operational events (lights turning on and off) that will occur if the "**End**" button is pressed at **1:10pm**.

Time	Event (Light ON or OFF)
1:00pm	**Red** and **Blue** both turn on
1:05pm	**Yellow** turns on
1:10pm	**Blue** turns off
1:15pm	**Yellow** turns off (since Timer_B is disabled immediately when .DN is set) **Green** turns on but immediately turns back off due to ONS. Note – Red stays on
No further changes occur as long as no buttons are pushed	

d) Beginning at 1:00pm, specify the sequence of operational events (lights turning on and off) that will occur if the "End" button is pressed at 1:20pm.

Time	Event (Light ON or OFF)
1:00pm	**Red** and **Blue** both turn on
1:05pm	**Yellow** turns on
1:15pm	**Green** turns on but immediately turns back off due to ONS.
1:20pm	**Blue** and **Yellow** turn off Note – Red stays on
No further changes occur as long as no buttons are pushed	

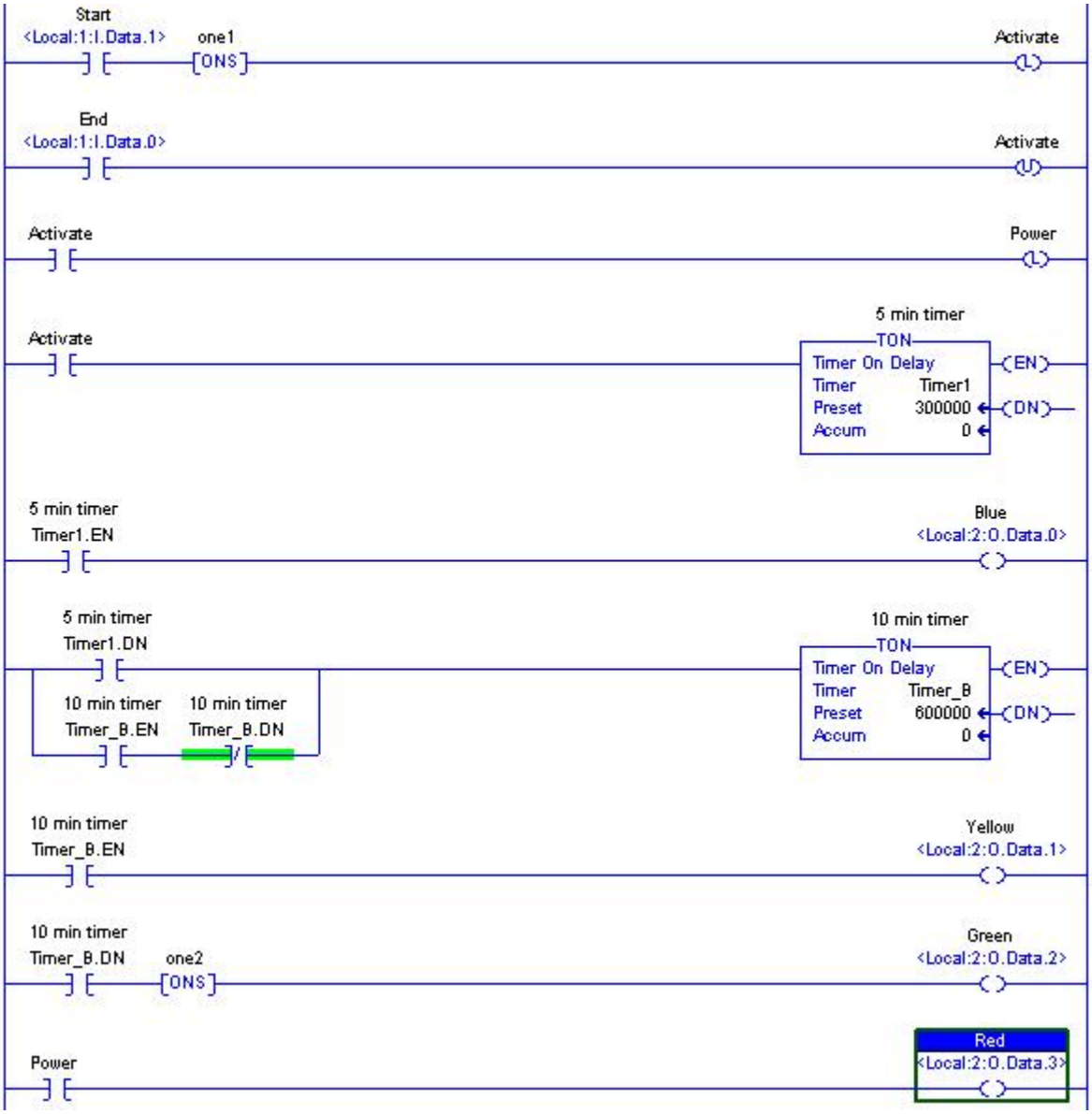


Figure P3 – Ladder Diagram and Wiring Diagram for Problem #3

Problem #4) Specify whether each of the following statements are true or false by **printing** either "**TRUE**" or "**FALSE**" in the blank answer space preceding each statement.

True Although the VFD can be configured to receive a "start" command **either** from the green button on its front panel or from the PLC by means of the VFD:O.Start instruction, the VFD will always accept a "stop" command from both sources.

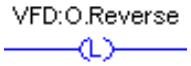
True The instruction <Timer_1.DN> will activate (close) when the value stored in the Accumulator of Timer_1 reaches the timer's Preset value, and it will remain active from that point on as long as the timer remains Enabled.

False An Overload Relay operates on a time-curve during start-up to avoid shutting-down the motor due to the large currents that it normally draws during "start-up", but then it responds instantaneously to overloads once the motor is fully operational. **←Red is False**

True Although contactors are designed to be able to disconnect an energized motor from its supply lines (i.e. – shut-down the motor) even during overload conditions, contactor's are not designed to interrupt short-circuit or other similarly large currents.

False A Normally Closed (NC) Auxiliary Contact is often used to “hold-in” a contactor after the “start” pushbutton in a motor control system is pressed and then released.

False A “series-resistance” motor starter requires two contactors that are energized simultaneously when starting an induction motor.

False When using the 

instruction to reverse the direction of the VFD, the “Forward” bit within the VFD’s memory will automatically be unlatched.

False When entering a ladder diagram into the RSLogix5000 software, a column of **e**’s will appear to the left of the rung to signify that there has been an error in the configuration of one of the instructions contained on the rung **or that the rung is incomplete (in error)**.
Green would make the statement True↗

False BOOTP is a software process that runs on the PLC and is used to assign an IP address to the computer used to program the PLC across the Ethernet network.

True An “alias-type” tag is a tag that refers to either a previously-defined alias-type or base-type tag that has a different name tag-name.

False Although removing power from the VFD will cause it to lose its IP Address, the PLC is able to retain its IP Address when power is removed from the device as currently configured in the Q-215 lab.

True The MOV command is used to copy data from one memory location to another (possibly remote) memory location.

False Sending a frequency value of 30Hz to the **VFD:O.FreqCommand** memory location within the VFD will immediately cause the drive vary its output frequency such that it is supplying its motor-load with a 30Hz set of AC waveforms **provided that the drive has already been activated (started)**.

True The MAC Address of a device on an Ethernet network is the unique physical address that is permanently assigned to the device.

True When an operational VFD is instructed to reverse the direction of its motor-load, the VFD will first lower the frequency of its output voltages to zero in order to stop the motor, after which it will re-accelerate the motor in the reverse direction by supplying the motor with a negative-sequence set of three-phase voltage waveforms.