(Take-Home)

Exam I part B

Due – By the beginning of the next lecture session.

Instructions:

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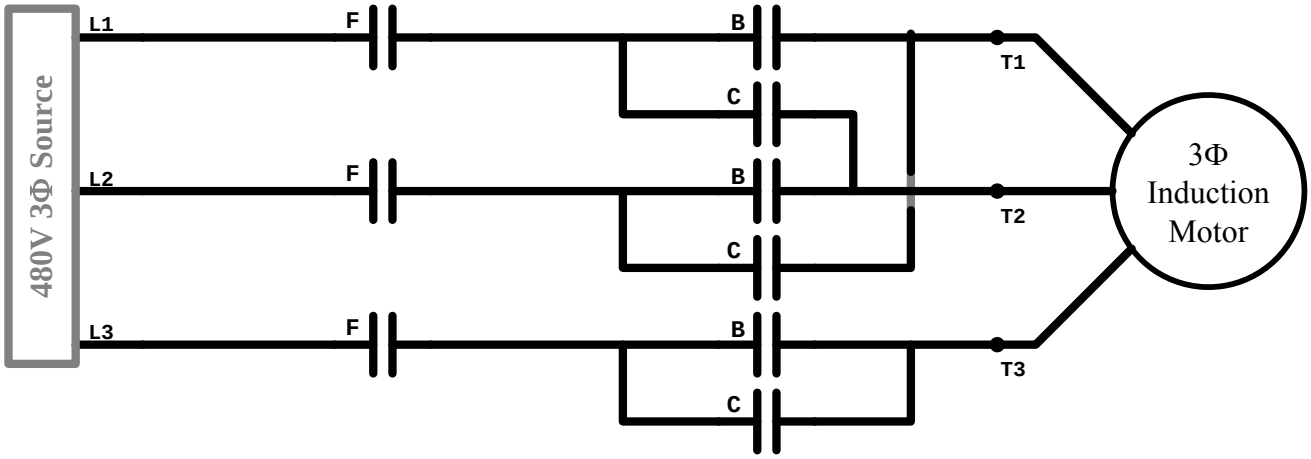
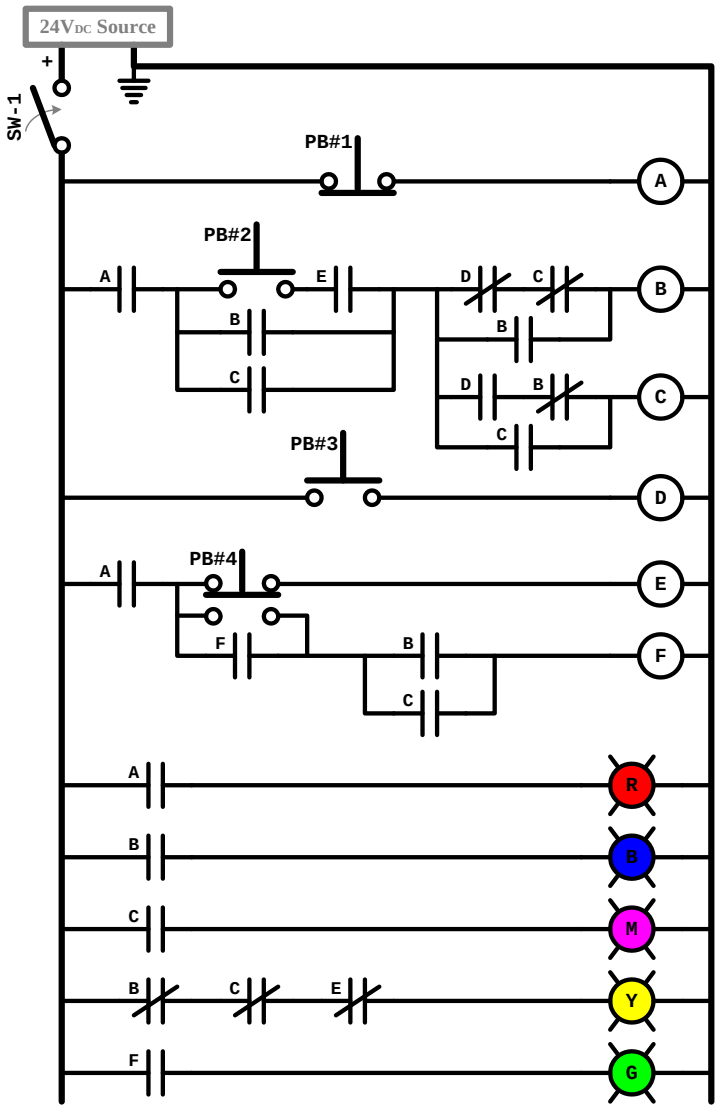
Sign Name: _____

Print Name: _____

This page must be attached to the exam booklet as its cover-page.

Problem #1) The following figures show a 460V, 3Φ Induction motor along with the motor control circuit.





Note – the "power" portion of the circuit is set-up such that the motor is configured for "Forward" operation when the "B" contacts are closed, and the motor is configured for "Reverse" operation when the "C" contacts are closed.

a) Specify a logical (one or two word) **name** or **label** for each of the push-buttons and indicator lamps that could be printed next to each of those devices on the system's control panel in order to provide the operator with information relating to the function or purpose of each specific device.

b) Assuming that SW-1 has been switched "**ON**" and that no push-buttons have been pressed, specify the exact **set of steps** that an operator should follow in order to **start the motor** in the **reverse direction**. Be sure to state which (if any) buttons must be held-in or pushed simultaneously during this procedure. Additionally, specify which indicator lamps will be "**ON**" and "**OFF**" after each step is completed.

c) **Analyze the system** to determine if there are any **"improper" button pushes** that would **prevent the system from successfully starting** (in either the forward or reverse direction). **Justify** your answer.

d) **Analyze the system** to determine if there are any **"improper" button pushes** that would **prevent the system from successfully shutting-down by pressing Pb-1. (Not by SW-1)** **Justify** your answer.

e) **State** whether or not it is possible to **change the direction of the motor** while the motor is energized. **Justify** your answer.

Answers to Problem #1 parts (a) and (b):

a) Names/Labels:

SW-1: **Main Power** Red (**R**) Indicator: **Power**

PB#1: _____ Blue (**B**) Indicator: _____

PB#2: _____ Magenta (**M**) Indicator: _____

PB#3: _____ Yellow (**Y**) Indicator: _____

PB#4: _____ Green (**G**) Indicator: _____

b) Instructions for Starting the Motor in the Reverse Direction: (Leave any unused steps blank)

Step 1 – **Flip the "Power" switch to the "ON" position in order to energize the control system.**

Indicator Lamps: **R_ON_ B_OFF_ M_OFF_ Y_OFF_ G_OFF_** **(after step 1 is complete)**

Step 2 – _____

Indicator Lamps: **R_____ B_____ M_____ Y_____ G_____** **(after step 2 is complete)**

Step 3 – _____

Indicator Lamps: **R_____ B_____ M_____ Y_____ G_____** **(after step 3 is complete)**

Step 4 – _____

Indicator Lamps: **R_____ B_____ M_____ Y_____ G_____** **(after step 4 is complete)**

Step 5 – _____

Indicator Lamps: **R_____ B_____ M_____ Y_____ G_____** **(after step 5 is complete)**

Answers to Problem #1 parts (c), (d) and (e):

c) Improper Button-Press Analysis for Reverse Starting:

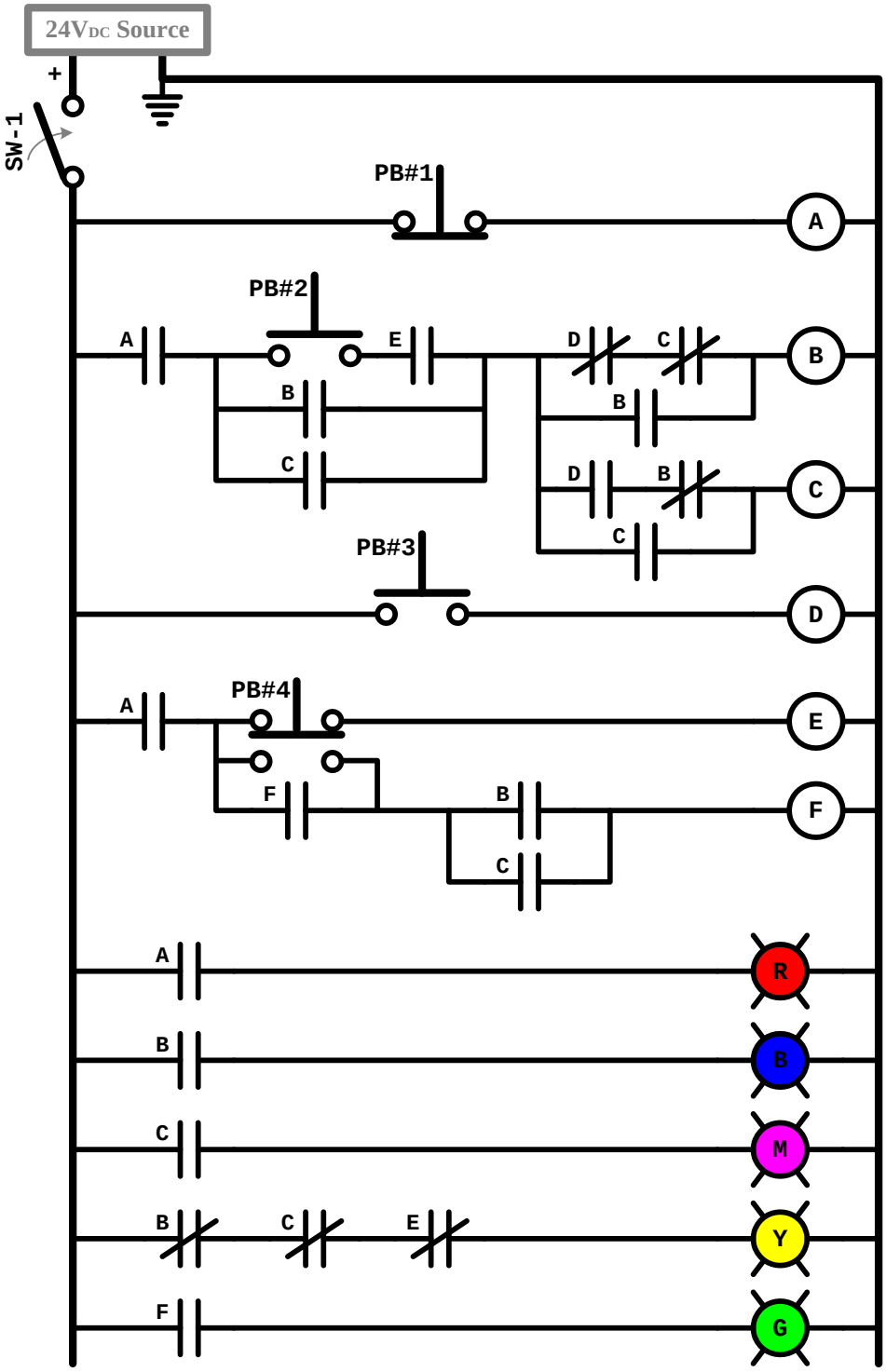
Analysis: _____

d) Improper Button-Press Analysis for Shutdown

Analysis: _____

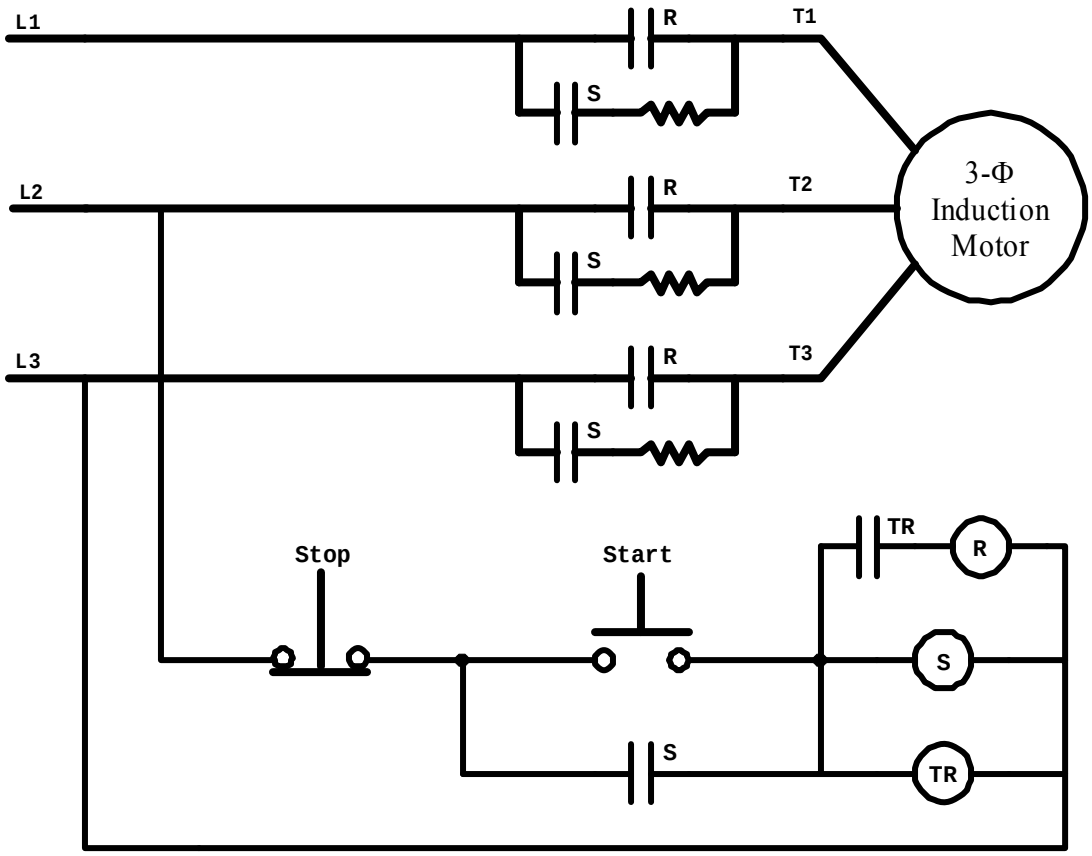
e) Is possible to change the direction while the motor is energized? _____ (YES or NO)

Justify your answer: _____



Full-Size Version of Control Circuit for Problem #1

Problem #2) The following figure shows a series-resistance motor starter:



Assuming that a normally-closed pushbutton is not available for the "Stop" button, re-design the control circuit such that it functions properly with a normally-open "Stop" button.

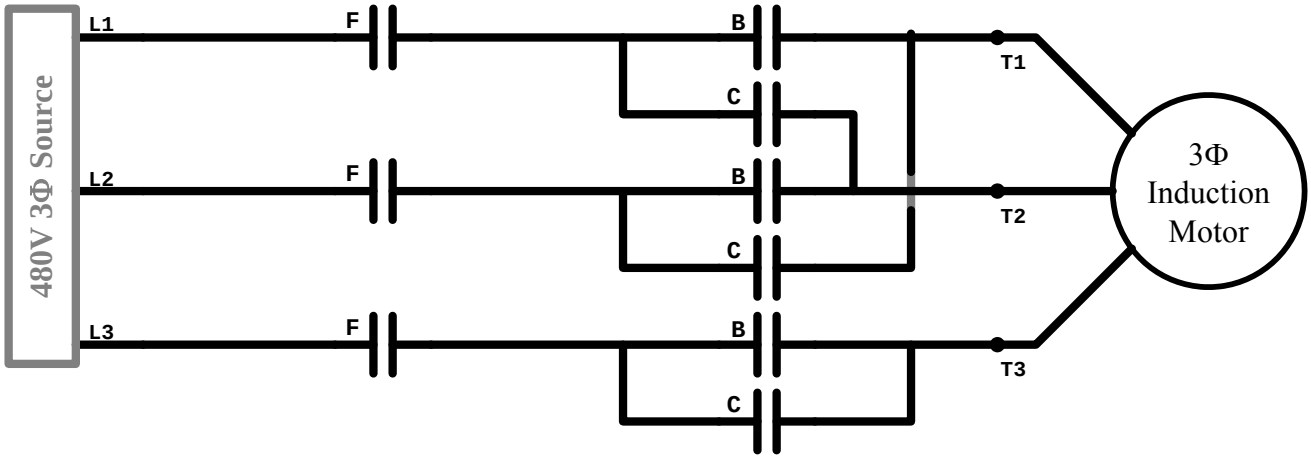
Note – You may incorporate additional components into your re-designed control circuit as necessary, including relays that contain both NO and NC contacts, provided that the overall function of the control system is maintained.

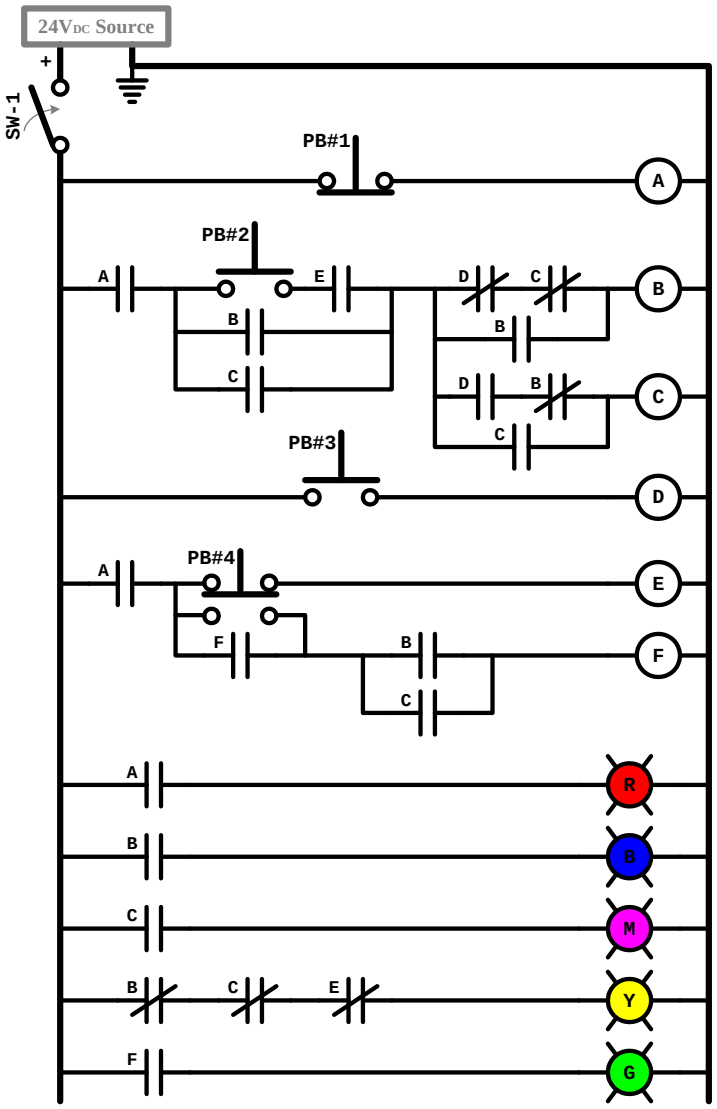
Also add "overload" protection into your re-designed system.

Neatly draw (using a straight-edge) an electric diagram that portrays your entire re-designed system on a blank piece of paper and staple it to this exam booklet immediately behind this page.

Be sure to label all the system's components with identifiers that properly link any associated components together. (I.e. – the "Run" contactor's field coil and contacts are all labeled "R")

Problem #1) The following figures show a 460V, 3Φ Induction motor along with the motor control circuit.





Note – the "power" portion of the circuit is set-up such that the motor is configured for "Forward" operation when the "B" contacts are closed, and the motor is configured for "Reverse" operation when the "C" contacts are closed.

a) Specify a logical (one or two word) **name** or **label** for each of the push-buttons and indicator lamps that could be printed next to each of those devices on the system's control panel in order to provide the operator with information relating to the function or purpose of each specific device.

b) Assuming that SW-1 has been switched "**ON**" and that no push-buttons have been pressed, specify the exact **set of steps** that an operator should follow in order to **start the motor** in the **reverse direction**. Be sure to state which (if any) buttons must be held-in or pushed simultaneously during this procedure. Additionally, specify which indicator lamps will be "**ON**" and "**OFF**" after each step is completed.

c) **Analyze the system** to determine if there are any **"improper" button pushes** that would **prevent the system from successfully starting** (in either the forward or reverse direction). **Justify** your answer.

d) **Analyze the system** to determine if there are any **"improper" button pushes** that would **prevent the system from successfully shutting-down by pressing Pb-1. (Not by SW-1)** **Justify** your answer.

e) **State** whether or not it is possible to **change the direction of the motor** while the motor is energized. **Justify** your answer.

ANSWERS TO PROBLEM #1 parts (a) and (b):

a) Names/Labels:

SW-1: Main Power — Red (**R**) Indicator: Power

PB#1: STOP/RESET — Blue (**B**) Indicator: FORWARD SET

PB#2: SET DIRECTION — Magenta (**M**) Indicator: REVERSE SET

PB#3: REVERSE ENABLE — Yellow (**Y**) Indicator: DIRECTION REQUIRED

PB#4: START MOTOR — Green (**G**) Indicator: MOTOR ENERGIZED

b) Instructions for Starting the Motor in the Reverse Direction: (Leave any unused steps blank)

Step 1 – **Flip the "Power" switch to the "ON" position in order to energize the control system.**

Indicator Lamps: **R** ON **B** OFF **M** OFF **Y** OFF **G** OFF **(after step 1 is complete)**

Step 2 – **Press and Hold PB#3 to Enable Reverse**

Indicator Lamps: **R** ON **B** OFF **M** OFF **Y** OFF **G** OFF **(after step 2 is complete)**

Step 3 – **Press PB#2 and then release both PB#2 and PB#3 to Set Reverse**

Indicator Lamps: **R** ON **B** OFF **M** ON **Y** OFF **G** OFF **(after step 3 is complete)**

Step 4 – **Press and release PB#4 to Start the Motor**

Indicator Lamps: **R** ON **B** OFF **M** ON **Y** OFF **G** ON **(after step 4 is complete)**

Step 5 – _____

Indicator Lamps: **R**_____ **B**_____ **M**_____ **Y**_____ **G**_____ **(after step 5 is complete)**

ANSWERS TO PROBLEM #1 parts (c), (d) and (e):

c) Improper Button-Press Analysis during Startup:

Analysis: _____

Holding-in PB#4 before PB#2 is pressed will prevent PB#2 from operating.

If PB#1 is pressed before PB#4 (step 4), then steps 2 & 3 must be repeated.

Note - step 2 is only required for reverse operation.

If the wrong direction is set, then PB#1 must be pressed to reset the direction, after which the process can be restarted.

d) Improper Button-Press Analysis for Shutdown

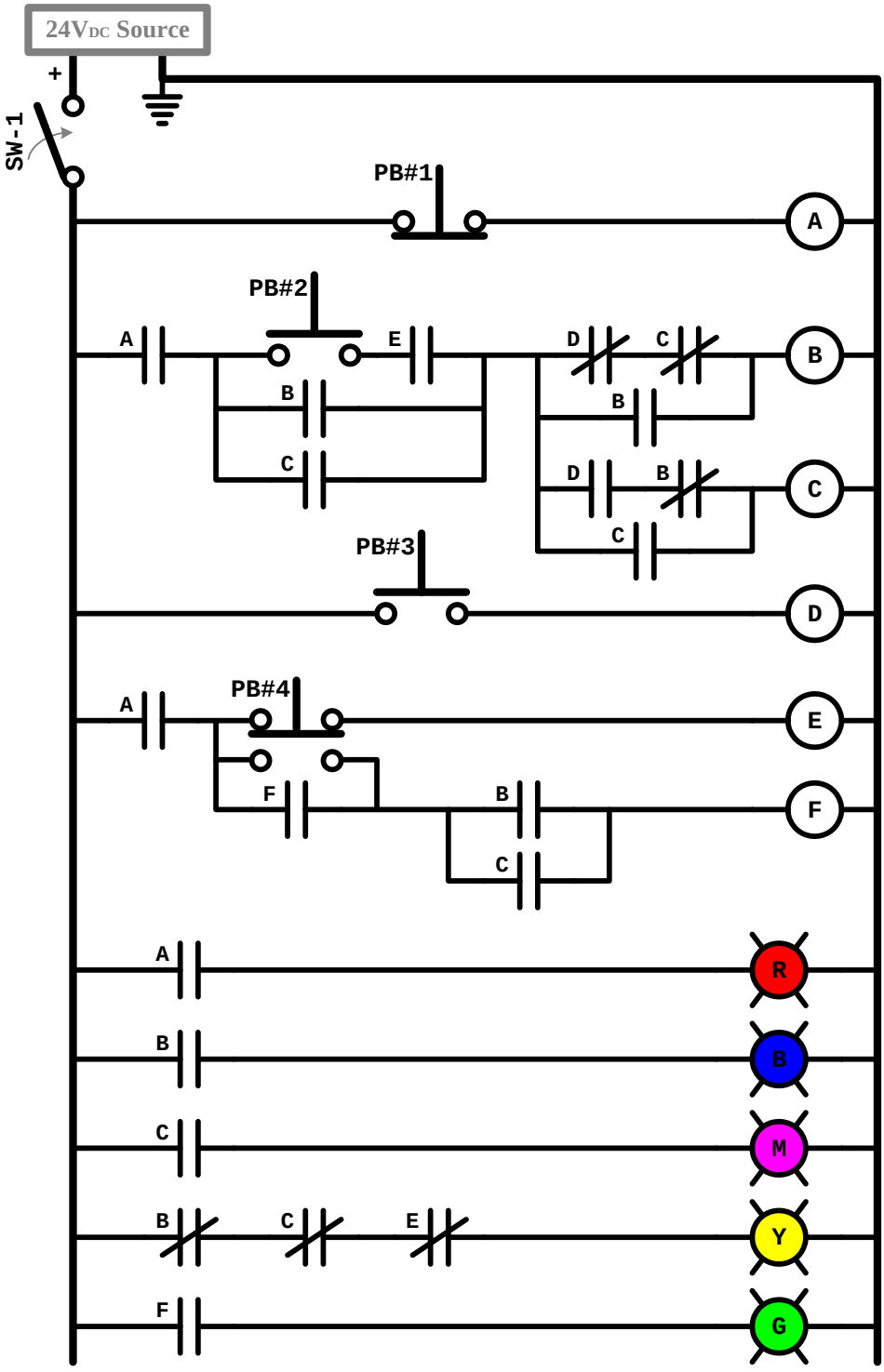
Analysis: _____

No… pressing PB#1 will de-energize contactor-A's field coil, causing A to drop-out, in-turn de-energizing the other two "logic" rungs and thus all of the other field-coils. No other button-presses can prevent this.

e) Is possible to change the direction while the motor is energized? NO (YES or NO)

Justify your answer: _____

The direction must be set before the coil-F (the motor) can be energized, and the only way to change the direction is to "Reset" the direction (PB#1), which also causes the motor to be de-energized.



Full-Size Version of Control Circuit for Problem #1

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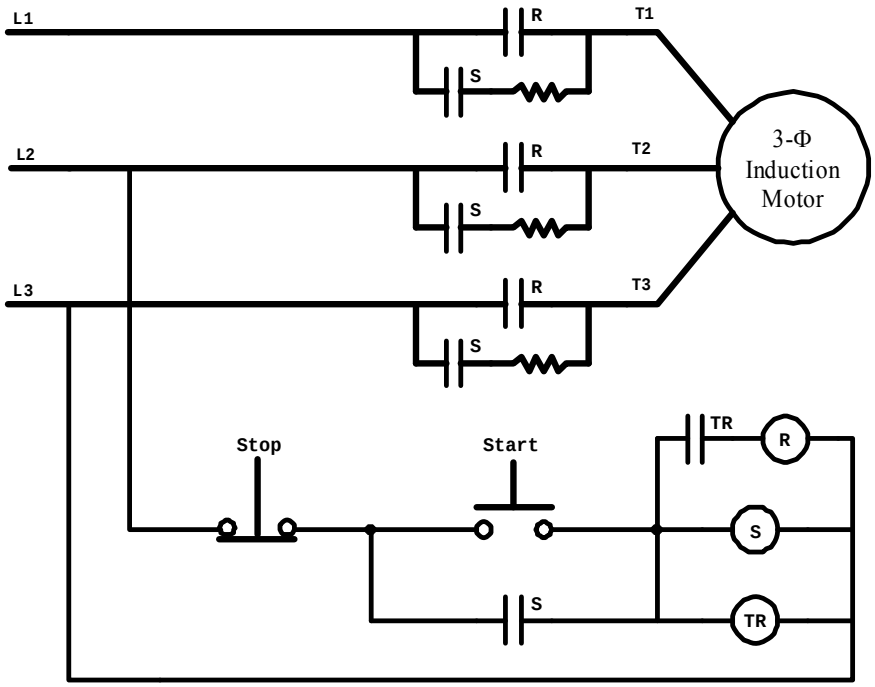
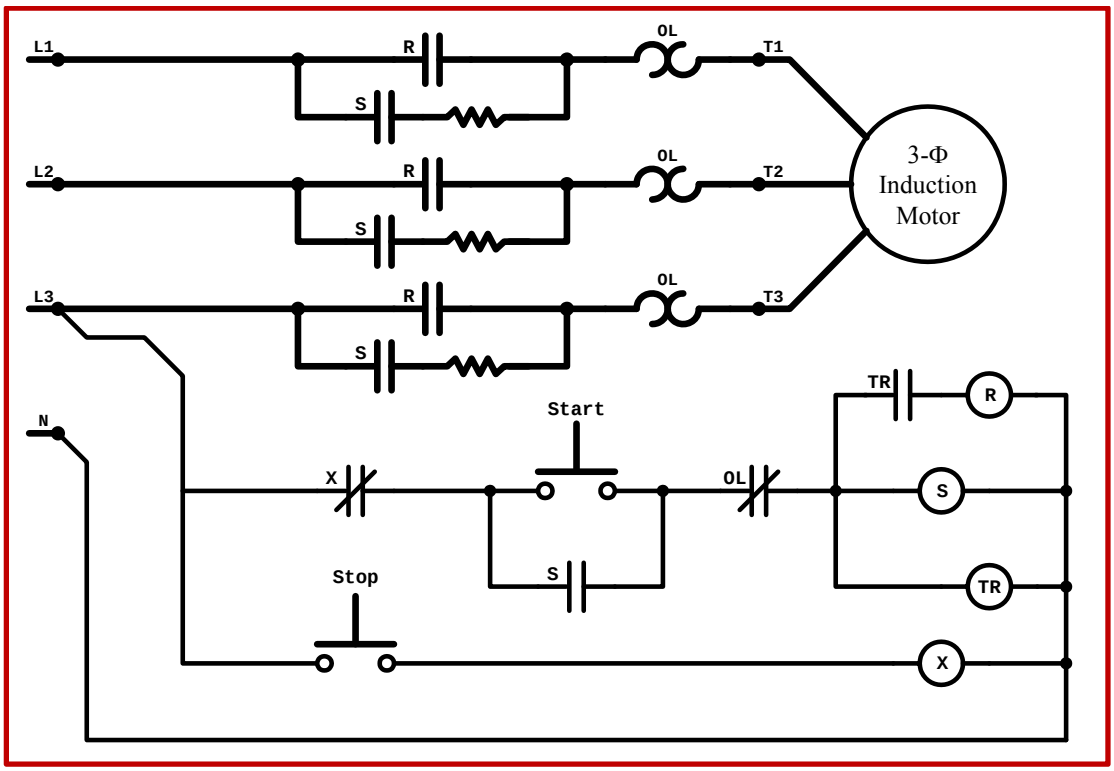


Assuming that a normally-closed pushbutton is not available for the "Stop" button, re-design the control circuit such that it functions properly with a normally-open "Stop" button.

Also add "overload" protection into your re-designed system.

Be sure to label all the system's components with identifiers that properly link any associated components together. (I.e. – the "Run" contactor's field coil and contacts are all labeled "R")



ANSWER TO PROBLEM #2

(Take-Home)

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For the circuit shown in Figure B6:

Assume that there is a small time-delay between the time that the field-coil of a specific relay is energized and that relay's armature actuates.
(Note – when a relay's armature actuates, its NO contacts close and its NC contacts open.)

Likewise, assume that there is a small time-delay between the time that the field-coil of a specific relay is de-energized and that relay's armature drops-out.
(Note – when a relay's armature drops-out, its NO contacts re-open and its NC contacts re-close.)

Assume that both the NO contacts and the NC contacts associated with any specific relay will transition simultaneously (i.e. – from opened→closed or closed→opened) when that relay's armature either actuates or drops-out.

When describing the circuit's operation with respect to the pushbuttons, consider the pushbuttons as two-stage devices that are first pressed and then released.

When a pushbutton is either pressed or released, assume that enough time will pass for the circuit to reach a steady-state condition before that or any other pushbutton is pressed or released.

Problem #6) Refer to the circuit shown in Figure B6 for all parts of this problem:

a) Assuming that all of the relay field-coils in the circuit are initially de-energized, specify the shortest **set of steps** (pushbutton presses and releases) that an operator can complete in order to continuously **illuminate the Green indicator light**.

Additionally, for each step, specify the exact order in which the armatures of the relays either actuate or drop-out if performing that step results in a change in the operational state of one or more or the relays.

Step 1 – **Press PB1 → A actuates → Amber ON**

Release PB1 → No further changes

Step 2 – _____

_____

Step 3 – _____

_____

Step 4 – _____

_____

Step 5 – _____

_____

Step 6 – _____

_____

b) Assuming that all of the relay field-coils in the circuit were initially de-energized before an operator completed the exact set of steps that you specified for part (a), specify the additional steps that the operator can complete in order to **extinguish (turn-off) both the Amber and the Green lights**.

Step 1 – _____

_____

Step 2 – _____

_____

Step 3 – _____

_____

c) Assuming that all of the relay field-coils in the circuit are once-again de-energized, if an operator first presses and then releases PB1 after which the operator presses and then releases PB2, specify the shortest **set of steps** (pushbutton presses and releases) that the operator can complete in order to **extinguish (turn-off) the Amber indicator light**.

Step 1 – _____

_____

Step 2 – _____

_____

Step 3 – _____

_____

d) Assuming that all of the relay field-coils in the circuit are once-again de-energized, if an operator first presses and then releases PB1 after which the operator presses and then releases PB2, are there any additional steps that the operator can complete in order to continuously **illuminate the Green indicator light** without first extinguishing (turning-off) the Amber indicator light?

State and justify your answer in the space below: (If "yes" then briefly state the steps, but if "no" then state why the Green lamp can't be illuminated.)

(You may detach this page from the exam booklet)

The following control circuit that contains seven relays (A-G), four pushbuttons (PB1-PB4) and two indicator lamps (Amber & Green) is to be utilized for Problem #6 of this exam:

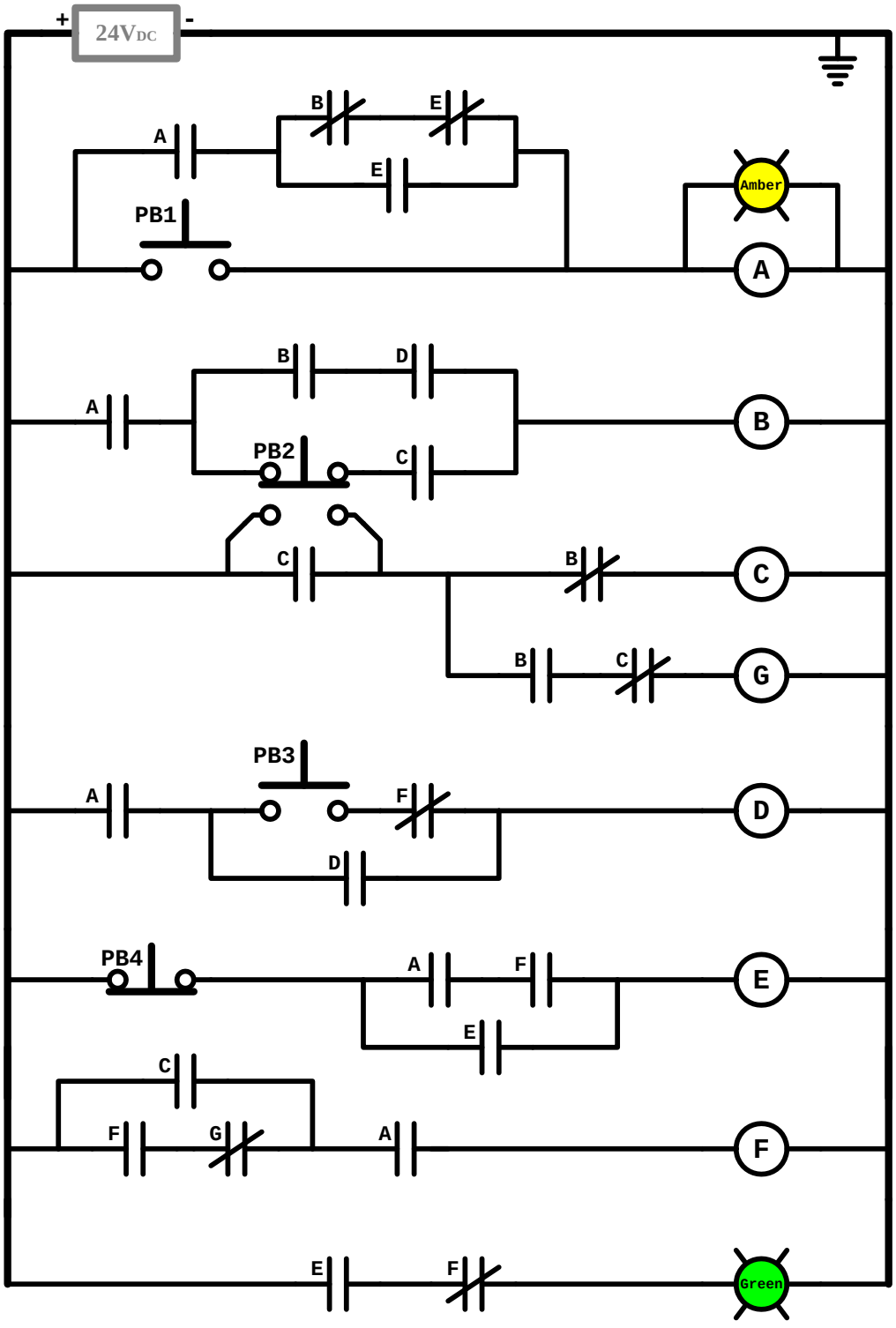

Figure B6 – Control Circuit for Problem #6