ECET 4530 – Industrial Motor Control **Sample Exam I part A – Version I – Problems**

Instructions: Place all final answers in the spaces provided.

Problem #1) 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.

_____ A **Series-Resistance Motor Starter** attempts to start a motor by initially supplying the motor through a set of series-connected resistors and then switching the resistors to a parallel-type of connection once the motor has accelerated to normal operational speeds.

_____ An **overload relay** operates on a **time-curve** such that the time-delay after which the relay trips varies with an inverse relationship compared to the magnitude of the overload current.

_____ **Contactors** are only designed to energize and de-energize a motor circuit when the motor is being supplied with a voltage that is less-than or equal-to its rated voltage and when the motor is drawing line currents that are less-than or equal-to its rated current.

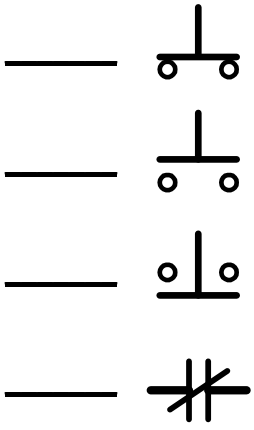
_____ The **direction** that a 3Φ Inductor Motor rotates can be reversed by swapping the terminals to which any two of its supply lines are connected.

_____ Although the main contacts of a contactor are initially used to connect a motor to its electrical supply, it is the contacts contained within the **overload relay** that actually disrupt the motor's currents during the occurrence of an overload.

_____ Since a motor naturally draws currents that are larger than rated current during startup, the operation of an **overload relay** must be temporarily disabled during startup or else the overload relay would prevent the motor from successfully starting.

_____ Starting a large induction motor by applying **full rated voltage** to its terminals can result in a large inrush current, the magnitude of which is often four to ten times larger than the motor's rated current.

Problem #2) Match the symbols shown in the left-hand column with the correct device listed in the right-hand column by writing the letter associated with the correct device next to the appropriate symbol.



A) Normally Open Pushbutton (shown in open position)

B) Normally Open Pushbutton (shown in closed position)

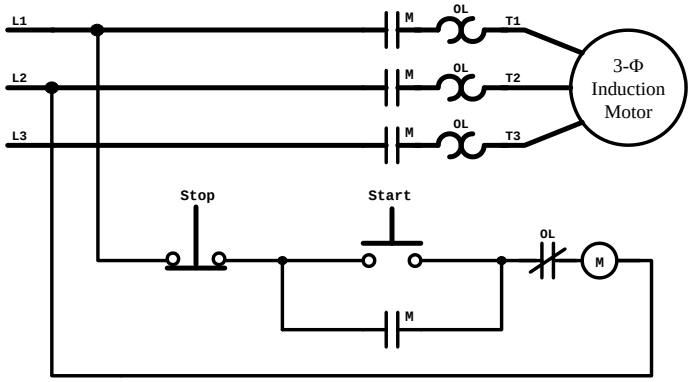
C) Normally Closed Pushbutton (shown in open position)

D) Normally Closed Pushbutton (shown in closed position)

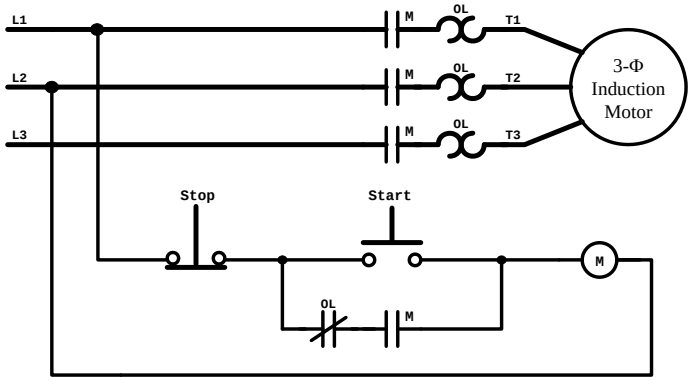
E) Normally Open Contact

F) Normally Closed Contact

Refer to the following diagram of a simple motor starter with overload protection for problems 3-5:



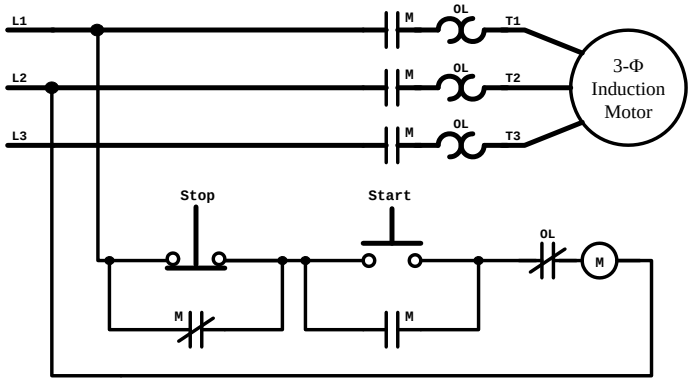
Problem #3) If a change is made to the simple motor starter as shown in Figure 3;



(Figure 3 – Modified Motor Starter Circuit)

Describe (and justify) any changes that will occur in the normal operation of the circuit:

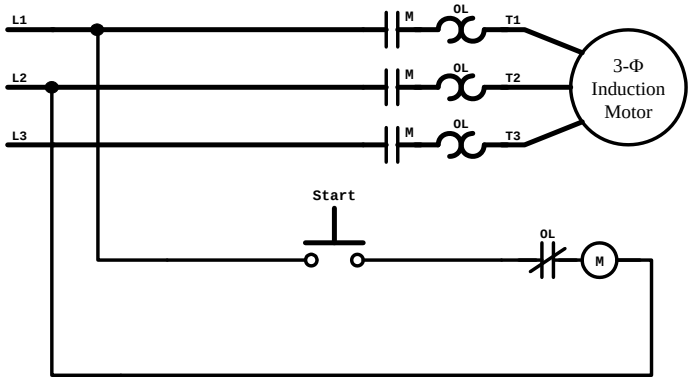
Problem #4) If a change is made to the simple motor starter as shown in Figure 4;



(Figure 4 – Modified Motor Starter Circuit)

Describe (and justify) any changes that will occur in the normal operation of the circuit:

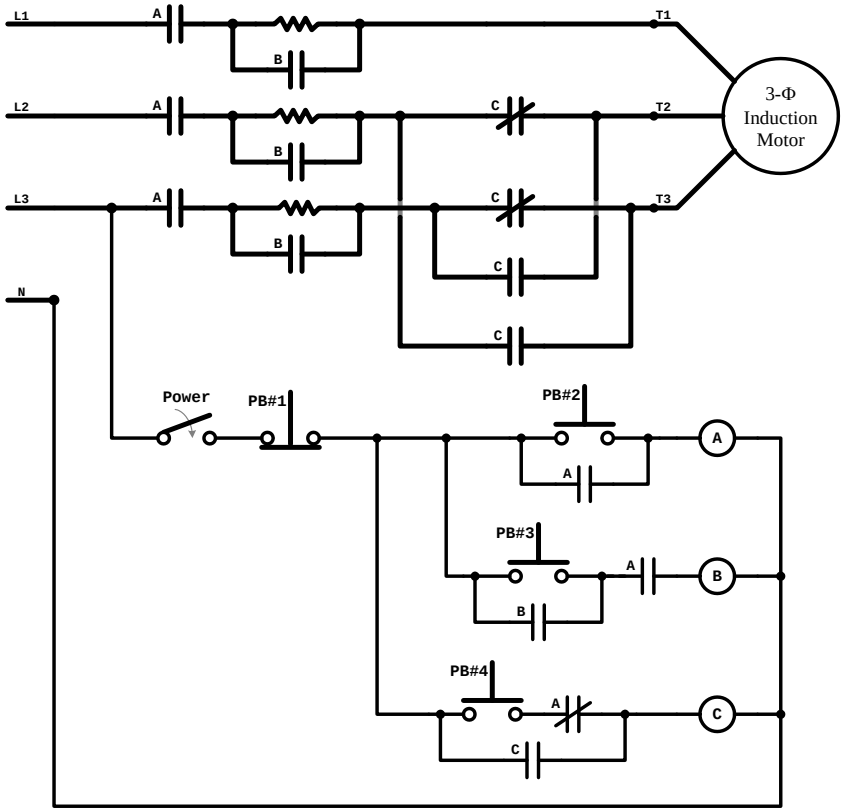
Problem #5) If a change is made to the simple motor starter as shown in Figure 5;



(Figure 5 – Modified Motor Starter Circuit)

Describe new operation of the circuit:

Refer to the following diagram of a series-resistance motor starter with directional control for problems 6-7:



Assuming that the "Power" switch is closed, the motor can be completely started by first pressing PB#2 and then pressing PB#3.

Problem #6) Can the direction of the motor be reversed after the motor is energized? State and justify your answer in the space below:

Problem #7) If the motor is started in a specific direction and then stopped (by pressing PB#1), after which it is restarted by pressing PB#2 and then pressing PB#3, will the motor always start again in the same direction? State and justify your answer in the space below:

ECET 4530 – Industrial Motor Control **Sample Exam I part A – Version I – Solutions**

Instructions: Place all final answers in the spaces provided.

Problem #1) 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 A **Series-Resistance Motor Starter** attempts to start a motor by initially supplying the motor through a set of series-connected resistors and then switching the resistors to a parallel-type of connection once the motor has accelerated to normal operational speeds.

TRUE An **overload relay** operates on a **time-curve** such that the time-delay after which the relay trips varies with an inverse relationship compared to the magnitude of the overload current.

FALSE **Contactors** are only designed to energize and de-energize a motor circuit when the motor is being supplied with a voltage that is less-than or equal-to its rated voltage and when the motor is drawing line currents that are less-than or equal-to its rated current.

TRUE The **direction** that a 3Φ Inductor Motor rotates can be reversed by swapping the terminals to which any two of its supply lines are connected.

FALSE Although the main contacts of a contactor are initially used to connect a motor to its electrical supply, it is the contacts contained within the **overload relay** that actually disrupt the motor's currents during the occurrence of an overload.

FALSE Since a motor naturally draws currents that are larger than rated current during startup, the operation of an **overload relay** must be temporarily disabled during startup or else the overload relay would prevent the motor from successfully starting.

TRUE Starting a large induction motor by applying **full rated voltage** to its terminals can result in a large inrush current, the magnitude of which is often four to ten times larger than the motor's rated current.

Problem #2) Match the symbols shown in the left-hand column with the correct device listed in the right-hand column by writing the letter associated with the correct device next to the appropriate symbol.

B 

A 

C 

F 

G) Normally Open Pushbutton (shown in open position)

H) Normally Open Pushbutton (shown in closed position)

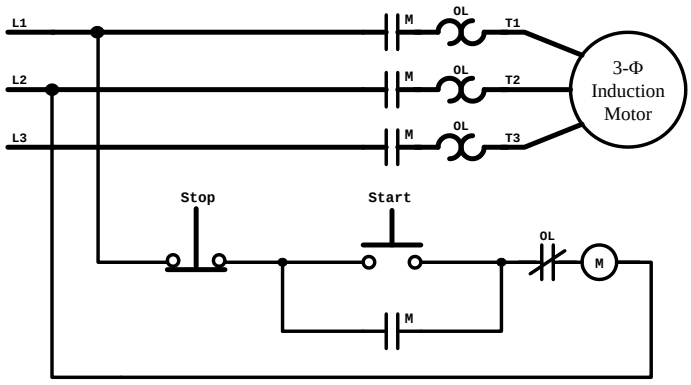
I) Normally Closed Pushbutton (shown in open position)

J) Normally Closed Pushbutton (shown in closed position)

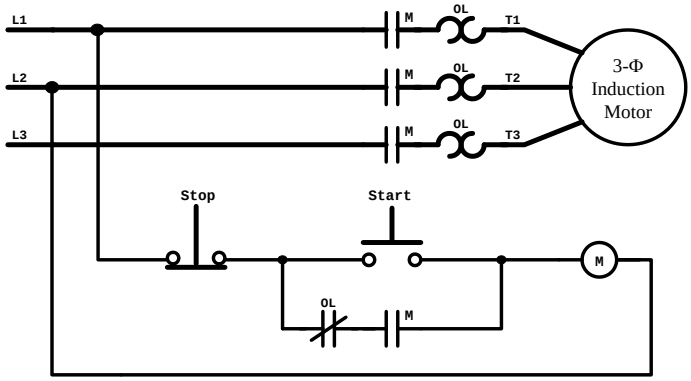
K) Normally Open Contact

L) Normally Closed Contact

Refer to the following diagram of a simple motor starter with overload protection for problems 3-5:



Problem #3) If a change is made to the simple motor starter as shown in Figure 3;



(Figure 3 – Modified Motor Starter Circuit)

Describe (and justify) any changes that will occur in the normal operation of the circuit:

No change in normal operation (until after an overload occurs)…

When "START" is pressed, the M hold-in contact closes, allowing M to remain energized through OL, even after "START" is released.

The "STOP" button functions normally.

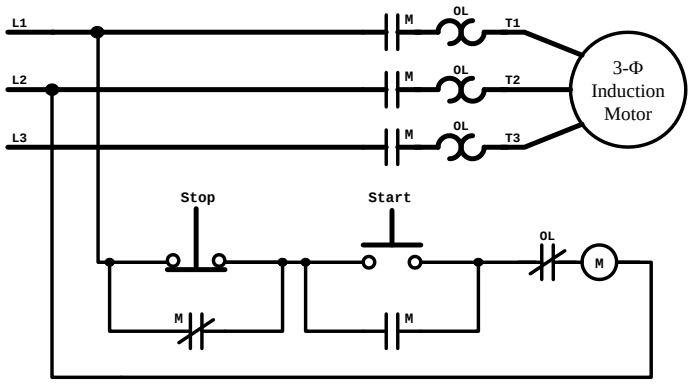
When an overload occurs, the OL contact opens, breaking the current path to M, causing the contactor to drop-out, in-turn de-energizing the motor.

After the occurrence of an overload…

Pressing the "START" button would cause the motor to begin to restart, even if the overload relay hasn't been reset and the OL contact is still open. But, as soon as the "START" button is released, the motor will again be de-energized.

Additionally, pressing and holding-in the "START" button would allow the motor to run continuously, even if the overload relay has tripped. Note that this would not be considered as "normal" operation of the circuit because the "START" button would not normally be held-in.

Problem #4) If a change is made to the simple motor starter as shown in Figure 4;



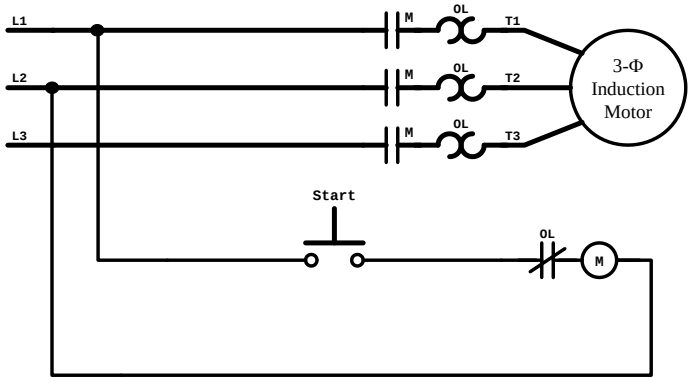
(Figure 4 – Modified Motor Starter Circuit)

Describe (and justify) any changes that will occur in the normal operation of the circuit:

No change in normal operation…

When "START" is pressed, the  **contact in-parallel with the "Stop" button opens, thus allowing "STOP" button to function normally.**

Problem #5) If a change is made to the simple motor starter as shown in Figure 5;



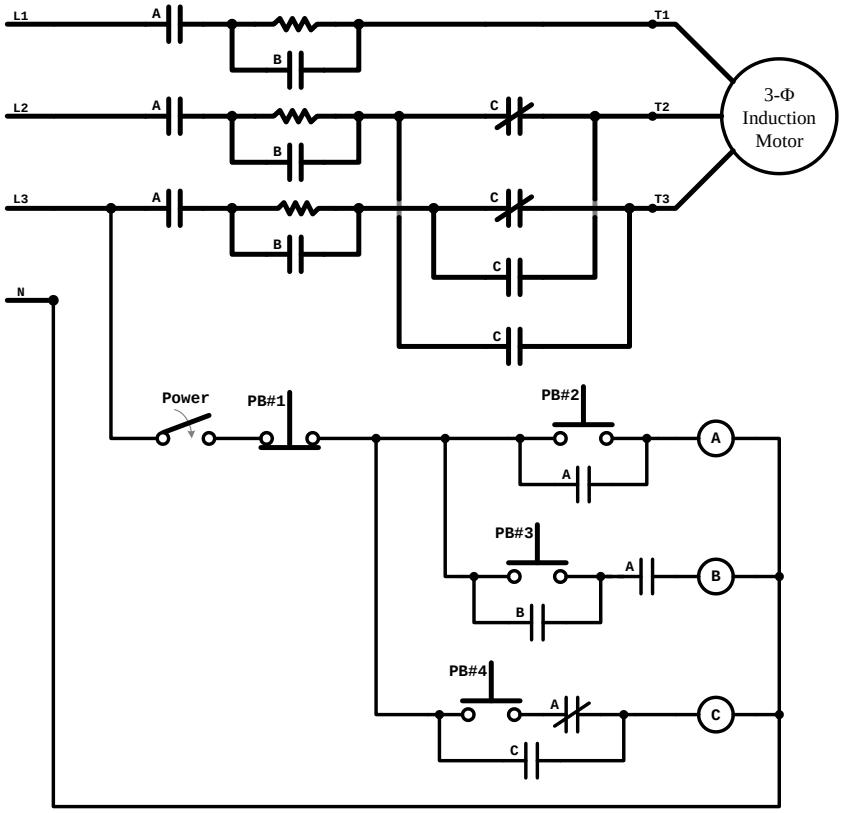
(Figure 5 – Modified Motor Starter Circuit)

Describe new operation of the circuit:

The motor will only operate while the "START" button is pressed and held-in. But, as soon as the "START" button is released, the motor will stop.

Note that the overload relay will stop the motor, even when the "START" button is held-in.

Refer to the following diagram of a series-resistance motor starter with directional control for problems 6-7:



Assuming that the "Power" switch is closed, the motor can be completely started by first pressing PB#2 and then pressing PB#3.

Problem #6) Can the direction of the motor be reversed after the motor is energized? State and justify your answer in the space below:

No, the direction of the motor cannot be reversed after the motor is energized…

Contactor-C determines the rotational direction of the motor. The motor will run "forward" if C is de-energized and the motor will run "in-reverse" if C is energized.

Once the motor is energized by initially energizing (A), the A contact that is connected in-series with PB#4 will open, preventing PB#4 from energizing (C) if it is not already energized.

And, if (C) is already energized, it can only be de-energized by pressing PB#1 (STOP).

Problem #7) If the motor is started in a specific direction and then stopped (by pressing PB#1), after which it is restarted by pressing PB#2 and then pressing PB#3, will the motor always start again in the same direction? State and justify your answer in the space below:

No… the motor defaults to the "forward" direction whenever it is stopped. Thus, if it was running in "reverse" before it was stopped, the motor will re-start in the "forward" direction unless PB#4 is pressed before the motor is restarted.

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

Instructions: Place all final answers in the spaces provided.

Problem #1) 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.

_____ A contactor typically contains a set of **Auxiliary Contacts** that can be used to replace its main contacts in case one of the main contacts fail to operate.

_____ An **overload relay** operates on a **time-curve** such that the time-delay after which the relay trips varies with an inverse relationship compared to the magnitude of the overload current.

_____ **Contactors** are only designed to energize and de-energize a motor circuit when the motor is being supplied with up-to rated voltage and when the motor is drawing line currents that are less-than or equal-to its locked-rotor current.

_____ The **direction** that a 3Φ Inductor Motor rotates can be reversed by swapping the terminals to which any two of its supply lines are connected.

_____ A **Variable Frequency Drive** (**VFD**) produces a set of variable-frequency 3Φ voltages, the magnitude of which do not change, in order to control the operational speed of a 3Φ Induction Motor.

_____ Since a motor naturally draws currents that are larger-than-rated current during startup, an **overload relay** is designed to operate on an inverse time-curve such that it does not prevent the motor from successfully starting.

_____ Starting a large induction motor by applying **full rated voltage** to its terminals can result in a large inrush current, the magnitude of which is often four to ten times larger than the motor's rated current.

Problem #2) Match the symbols shown in the left-hand column with the correct device listed in the right-hand column by writing the letter associated with the correct device next to the appropriate symbol.

_____ 

_____ 

_____ 

_____ 

M) Normally Open Pushbutton (shown in open position)

N) Normally Open Pushbutton (shown in closed position)

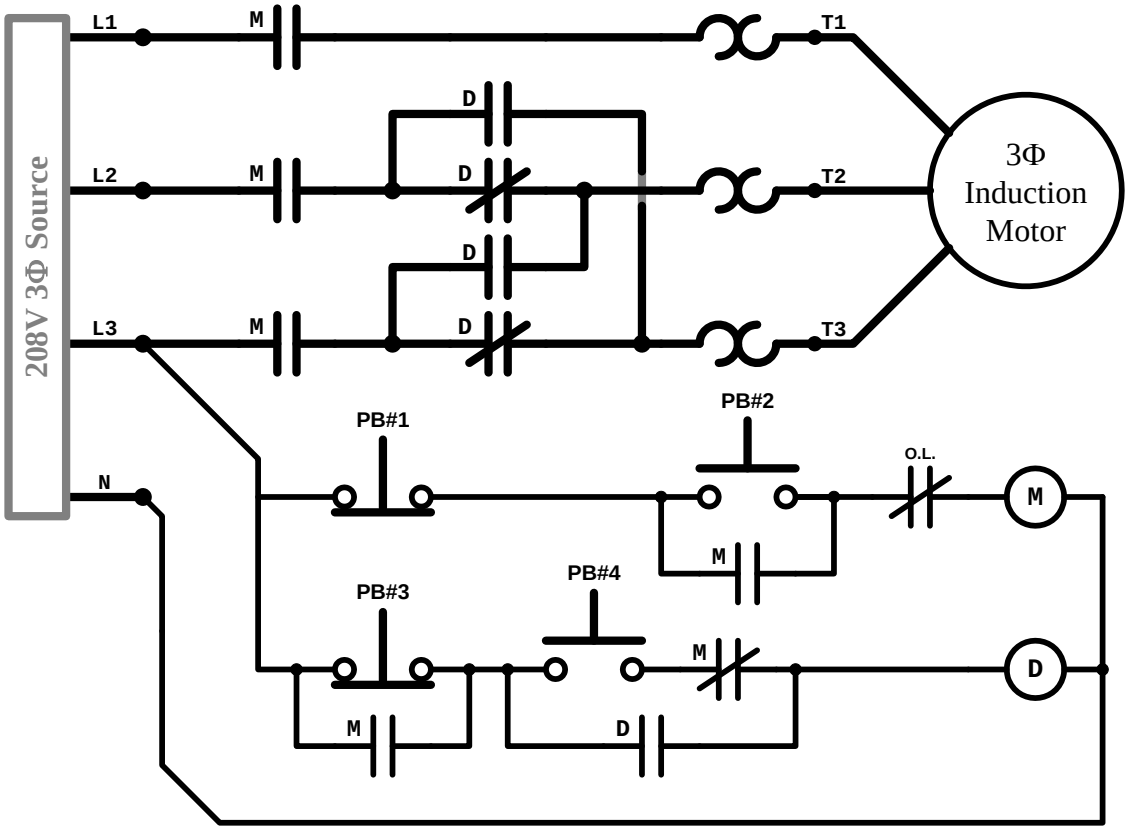
O) Normally Closed Pushbutton (shown in open position)

P) Normally Closed Pushbutton (shown in closed position)

Q) Normally Open Contact

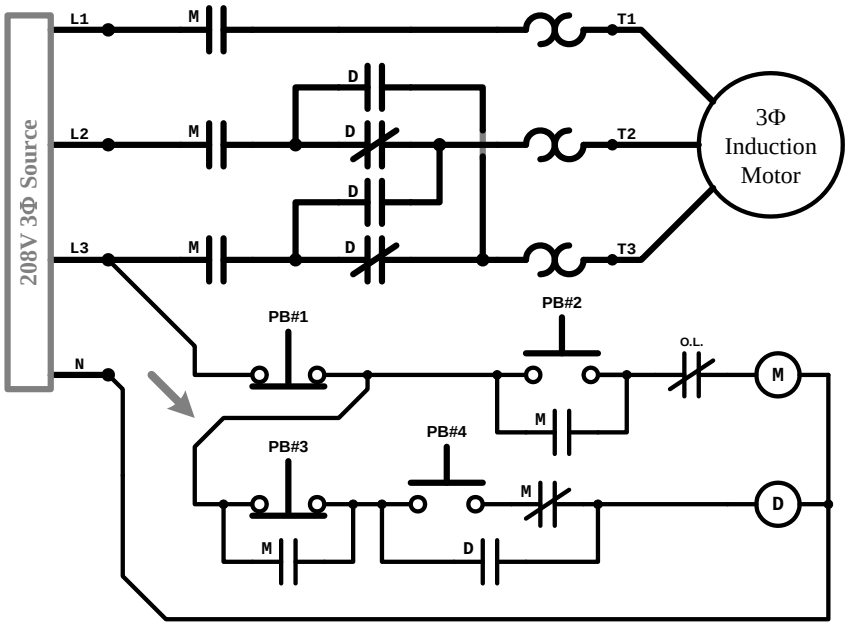
R) Normally Closed Contact

Refer to the following diagram of a reversible motor starter with overload protection for problems 3-4. You may assume that if Contactor-D is de-energized then the motor will rotate in the "forward" direction.



Problem #3) Describe in-detail the operation of the system shown above. Be sure to include information regarding the steps required to start and stop the motor and the steps required to set the motor's direction. Also discuss such topics as how the system will function when an overload occurs, how the system functions when the system is started again after being stopped, and if the motor's rotational direction can be changed while the motor is energized.

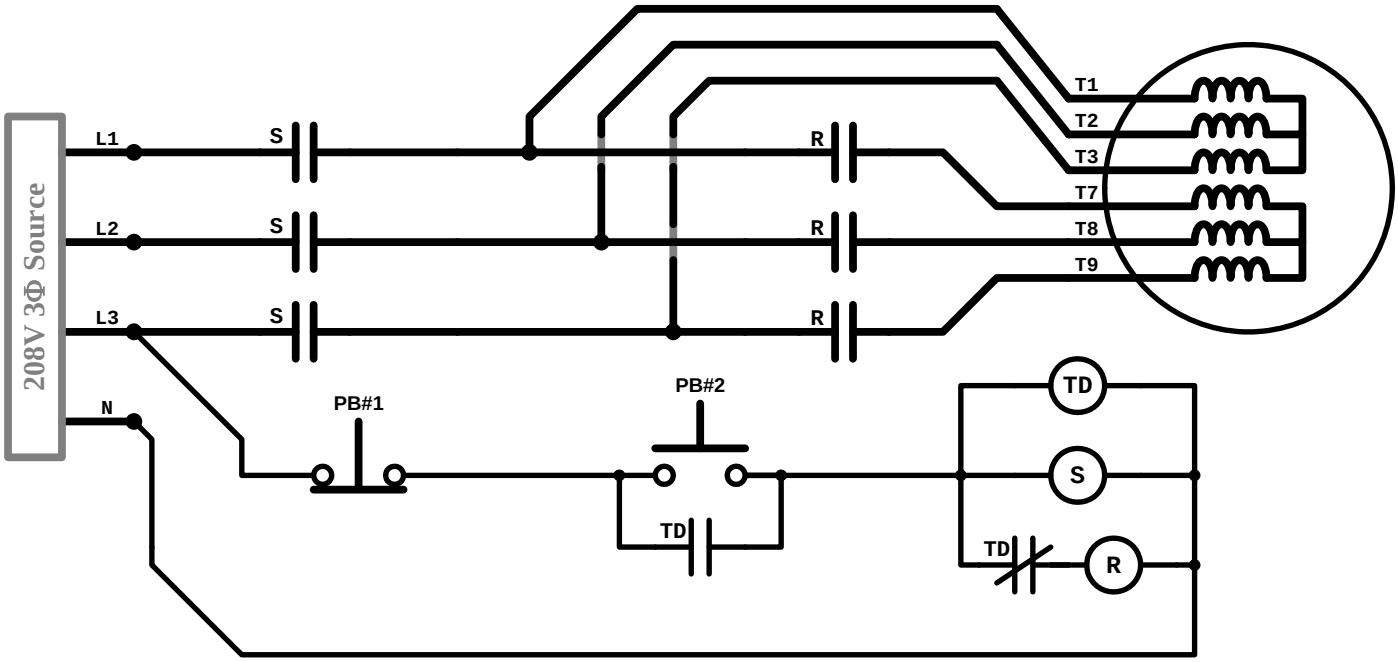
Problem #4) If a change is made to the system as shown in Figure 4;



(Figure 4 – Modified Motor Starter Circuit)

Describe in-detail any changes that will occur in the system's overall operation:

Problem #5) Given the system shown below:



Note – The "TD" components shown in the figure are part of a 2-second on-delay timer.

Describe the type of motor starter shown in the figure above and describe in-detail the operation of the system. Be sure to include information regarding the steps required to start and stop the motor.