Time Relay Circuits

UNIT OBJECTIVE

Upon completion of this unit, you will understand how time relays work. You will also be able to utilize solid-state time relays in applications requiring time delays.

DISCUSSION OF FUNDAMENTALS

Time relays are used in control, starting, and protective circuits for all switching operations involving time delays. Different pilot devices are employed to control the process of energizing or de-energizing timing relays.

Four main categories of time relays are:

- **Dashpot**: Old technology in which a time delay results from air or liquid going through a valve opening at a variable speed.

Figure 6-1. Dashpot time relay.

- **Synchronous clock (sequence timer)**: Contacts open and close at intervals depending on the position of the moving hands on a clock dial.

Figure 6-2. Synchronous Clock.

- **Solid-state**: The time delay is supplied by enclosed electronic devices. The Time Relay module, Model 3132, is of this type.
- **Programmable**: More complex control devices, such as programmable logic controllers (PLCs), often include timing functions.

Time Relays

EXERCISE OBJECTIVE

Become familiar with time relay features and applications.

DISCUSSION

The Time Relay, Model 3132, is a solid-state category time relay. This device, shown on Figure 6-3, has three adjustment potentiometers, which are controlling:

- Time delay value, in the range from 0 to 20 s
- Time delay adjustment, in the range from approximately 30 to 100% of the set time
- Function code, in the range from A to H

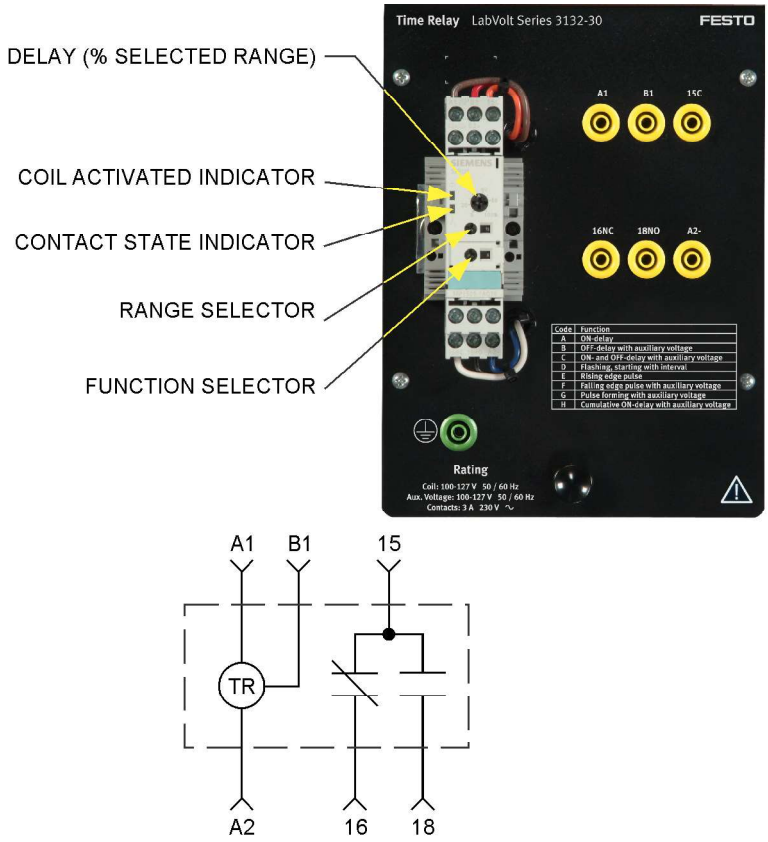

Figure 6-3. Time Relay, Model 3132.

Two indicator lights provide information about the Time Relay status. The one at the top indicates the coil state. The one at the bottom indicates the contact state.

Terminals of the Time Relay are as follows:

- A1–A2: supply voltage
- B1–A2: auxiliary voltage
- 15–16: NC contact
- 15–18: NO contact

Table 6-1 describes the different functions of this module with their associated code. The function codes are also indicated on the module faceplates.

Table 6-1. Time relay functions.

Function	Code	Description
On-delay	A	NO contact closes t seconds after the supply coil is energized, providing that the coil remains energized that long. No auxiliary voltage is needed.
Off-delay	B	NO contact closes as soon as the auxiliary voltage is turned on but opens t seconds after it is removed. The supply voltage is always on.
On- and Off-delay	C	Combination of on-delay and off-delay functions, with the same time delay t for on and off switching. The supply voltage is always on.
Flashing	D	NO contact opens and closes at equal intervals of t seconds, after the supply coil is energized. No auxiliary voltage is needed.
Rising edge pulse	E	NO contact closes for t seconds as soon as the supply coil is switched on. No auxiliary voltage is needed.
Falling edge pulse	F	NO contact closes for t seconds as soon as the auxiliary coil is switched off. The supply voltage is always on.
Auxiliary rising edge pulse	G	NO contact closes for t seconds as soon as the auxiliary coil is switched on. The supply voltage is always on.
Cumulative on-delay	H	NO contact closes once the auxiliary coil has been energized for a total of t seconds and opens next time the auxiliary coil de-energizes. The supply voltage is always on.

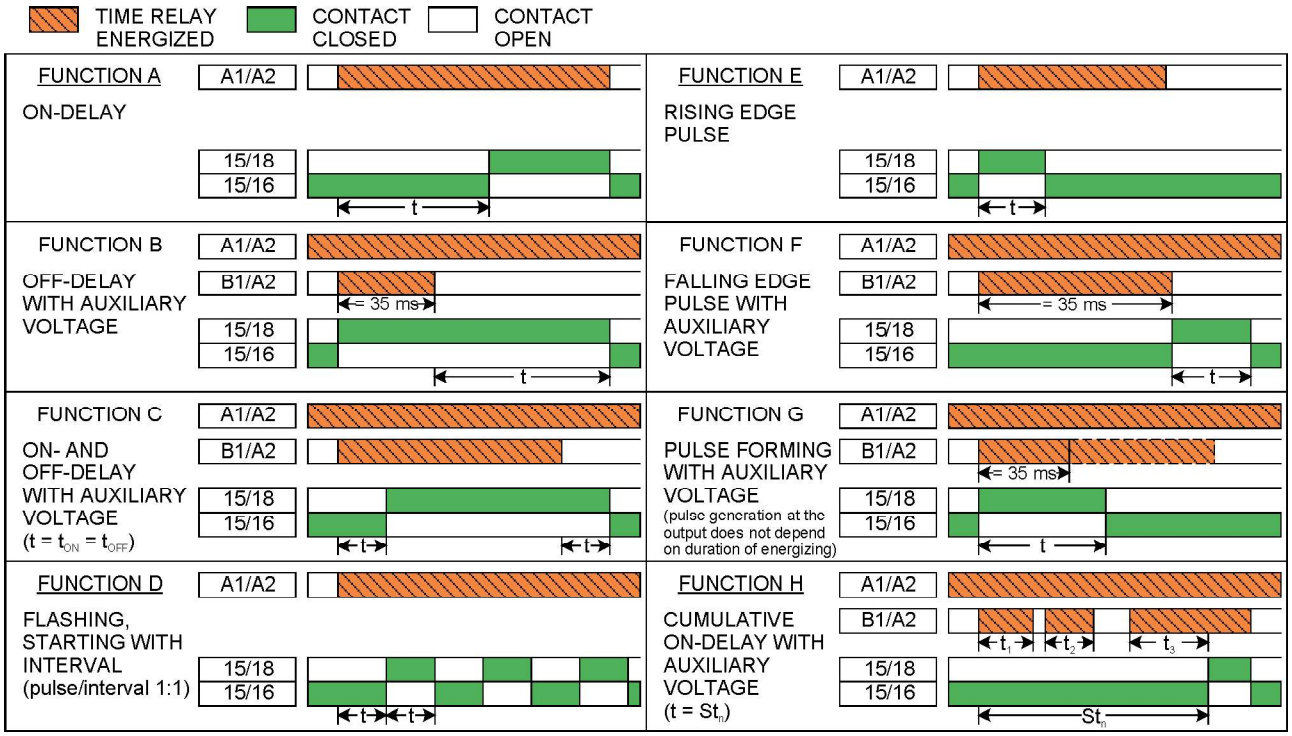

Figure 6-4. Time diagram.

Figure 6-5 shows a time-delay circuit. When the selector switch closes, the time relay coil is energized. If an on-delay is set, the NO contact closes after the preset time t, turning on the green light. Opening the selector switch de-energizes the circuit, turning off the green light.

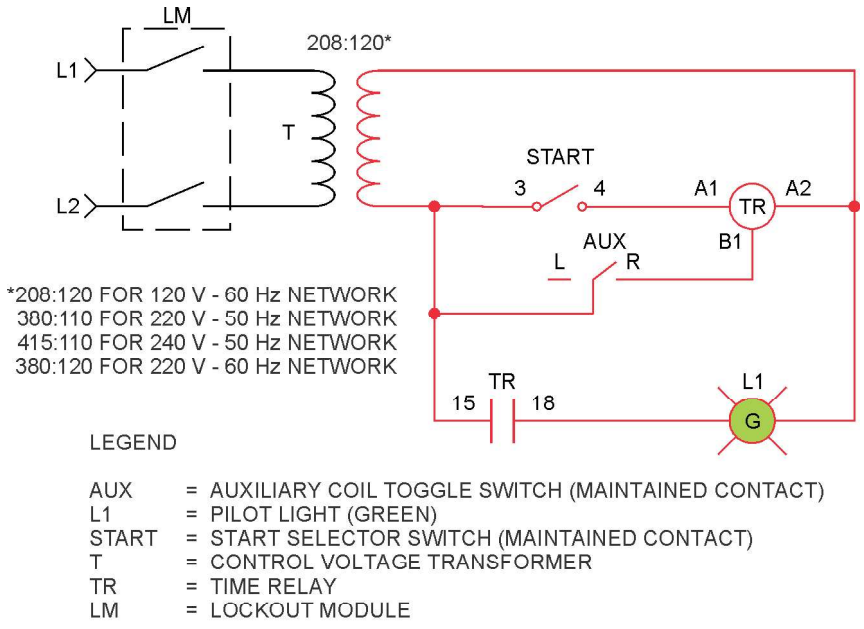

Figure 6-5. Basic time-delay circuit.

PROCEDURE OUTLINE

The Procedure is divided into the following sections:

- Basic setup
- On-delay function
- Off-delay function
- On- and Off-delay function
- Flashing

PROCEDURE

In the first part of this exercise, you will implement an On-delay function in a pilot light circuit. You will observe that this function works with supply voltage only and that a delay is produced before the NO contact closes. You will then modify the time adjustment potentiometer to change the set time delay.

In the second part of the exercise, you will change the time function for Off-delay. You will observe that this function works with supply and auxiliary voltages. A delay is produced after auxiliary voltage is lost, before the NO contact opens. The supply voltage must be provided at all times to make this function work.

In the third part of the exercise, you will try the On- and Off-delay function. You will discover that a delay is produced before the NO contact opens or closes, following a change in the auxiliary voltage. The supply voltage must be provided at all times to make this function work.

In the last part of the exercise, you will be asked to make a pilot light flash at a given rate. To do so, you will set the function code and time-delay value potentiometers to appropriate values.

⚠ WARNING

The AC Power Supply provides high voltages. Do not change any AC connection with the power on.

Basic setup

1. Perform the Basic Setup and Lockout/Tagout procedures.

On-delay function

2. Connect the circuit shown in Figure 6-5. Use the SS-1 contact of the Selector Switches module.

3. Set the Time Relay with the following parameter values:
   - Function code: A (On-delay)
   - Time-delay value: 10 s
   - Time-delay adjustment: 100%

Set the START selector switch of the Selector Switches to the O position (open contact).

4. Perform the Energizing procedure.

   Start the chronometer as you set the START selector switch of the Selector Switches to the L position (closed contact).

   Does the L1 pilot light turn on?

   ❑ Yes, immediately ❑ Yes, after a delay of ___ s ❑ No

5. Start the chronometer as you set the START selector switch to the O position (open contact).

   Does the L1 pilot light turn off?

   ❑ Yes, immediately ❑ Yes, after a delay of ___ s ❑ No

6. Change the time-delay adjustment to 50%.

   Start the chronometer as you set the START selector switch to the L position.

   Does the L1 pilot light turn on?

   ❑ Yes, immediately ❑ Yes, after a delay of ___ s ❑ No

7. Set the START selector and the AUX toggle switches of the Selector Switches to the O position.

Off-delay function

8. Set the Time Relay with the following parameter values:
   - Function code: B (Off-delay)
   - Time-delay value: 10 s
   - Time-delay adjustment: 100%

9. Start the chronometer as you set the START selector switch to the L position.

   Does the L1 pilot light turn on?

   ❑ Yes, immediately ❑ Yes, after a delay of ___ s ❑ No

10. Explain what happens (refer to the Figure 6-4 time diagram if necessary).

_____

_____

_____

11. Start the chronometer as you set the AUX toggle switch to the R position.

Does the L1 pilot light turn on?

❑ Yes, immediately ❑ Yes, after a delay of ___ s ❑ No

12. Explain what happens (refer to the Figure 6-4 time diagram if necessary).

_____

_____

_____

13. Start the chronometer as you set the AUX toggle switch to the O position.

Does the L1 pilot light turn off?

❑ Yes, immediately ❑ Yes, after a delay of ___ s ❑ No

14. Explain what happens (refer to the Figure 6-4 time diagram if necessary).

_____

_____

_____

15. Set the START selector and the AUX toggle switches to the O position.

On- and Off-delay function

16. Set the Time Relay with the following parameter values:

- Function code: C (On- and Off-delay)
- Time-delay value: 10 s
- Time-delay adjustment: 100%

17. Start the chronometer as you set the START selector switch to the L position.

Does the L1 pilot light turn on?

❑ Yes, immediately ❑ Yes, after a delay of ___ s ❑ No

18. Explain what happens (refer to the Figure 6-4 time diagram if necessary).

_____

_____

_____

19. Start the chronometer as you set the AUX toggle switch to the R position.

Does the L1 pilot light turn on?

❑ Yes, immediately ❑ Yes, after a delay of ___ s ❑ No

20. Explain what happens (refer to the Figure 6-4 time diagram if necessary).

_____

_____

_____

21. Start the chronometer as you set the AUX toggle switch to the O position.

Does the L1 pilot light turn off?

❑ Yes, immediately ❑ Yes, after a delay of ___ s ❑ No

22. Explain what happens (refer to the Figure 6-4 time diagram if necessary).

_____

_____

_____

23. Set the START selector and the AUX toggle switches to the O position.

Flashing

24. Using the same circuit, set the time relay so that the L1 pilot light turns on or off every 1.5 seconds with a time-delay adjustment potentiometer set to 50%.

What function code and time-delay value have you set on the Time Relay?

Function code: _____

Time-delay value: _____

25. Confirm your settings by testing the circuit operation.

26. Turn the individual power switch of the AC Power Supply off, disconnect the circuit, remove the magnetic labels, and return the equipment to the storage location.

CONCLUSION

Time relays enable delaying an action in a control, starting, or protective circuit. Dashpot and synchronous clock time relays are the oldest and most simple types of time relays. They are operated by mechanical means.

Solid-state and programmable time relays are electronically piloted and permit more functions. On-delay, off-delay, flashing, rising edge pulse, and falling edge pulse are some common time functions.

REVIEW QUESTIONS

1. Which time relay type supplies a time delay corresponding to the position of the hand on the dial?

   a. Dashpot

   b. Synchronous clock

   c. Solid-state

   d. Programmable

2. Which time relay type offers the most complex time functions?

   a. Dashpot

   b. Synchronous clock

   c. Solid-state

   d. Programmable

3. Which time function of the Time Relay, Model 3132, causes the starting signal to be delayed, but not the stop signal?

   a. Rising edge pulse (code E)

   b. On- and off- delay (code C)

   c. Off-delay (code B)

   d. On-delay (code A)

4. Which time function of the Time Relay, Model 3132, causes the starting and the stop signals to be delayed?

   a. Rising edge pulse (code E)

   b. On- and off- delay (code C)

   c. Off-delay (code B)

   d. On-delay (code A)

5. If you refer to Figure 6-4, which Time Relay module function does not need auxiliary voltage to work properly?

   a. Rising edge pulse (code E)

   b. On- and off- delay (code C)

   c. Off-delay (code B)

   d. None of the functions above is correct.

Plugging with Time Relays

EXERCISE OBJECTIVE

Understand how a time relay can be used for plugging.

DISCUSSION

Plugging is a motor braking method that uses the counter torque produced by reversing two power lines. In Exercise 3-4, you started a plugging operation by pressing the forward push button while the motor was running in reverse direction. As the motor stopped, you had to press the stop push button to prevent the motor from rotating in the opposing direction.

When it is not possible for an operator to check when the motor is stopped, an automatic means of stopping the motor power supply must be found. A time relay can be utilized for this purpose, provided that the time the motor needs to stop is known in advance.

Figure 6-6 is a plugging circuit using a time relay to stop the motor before it rotates backwards. To make the motor turn in the forward direction, the START push button is pressed. The STOP push button makes the motor coast to a stop. The FSTOP (fast stop) push button opens the forward contactor and activates the reverse contactor, making the motor stop rapidly. The On-delay function of the time relay opens the reverse contactor a preset time t after the forward contactor is de-energized. If it is chosen properly, the motor stops exactly when the reverse contactor is de-energized.

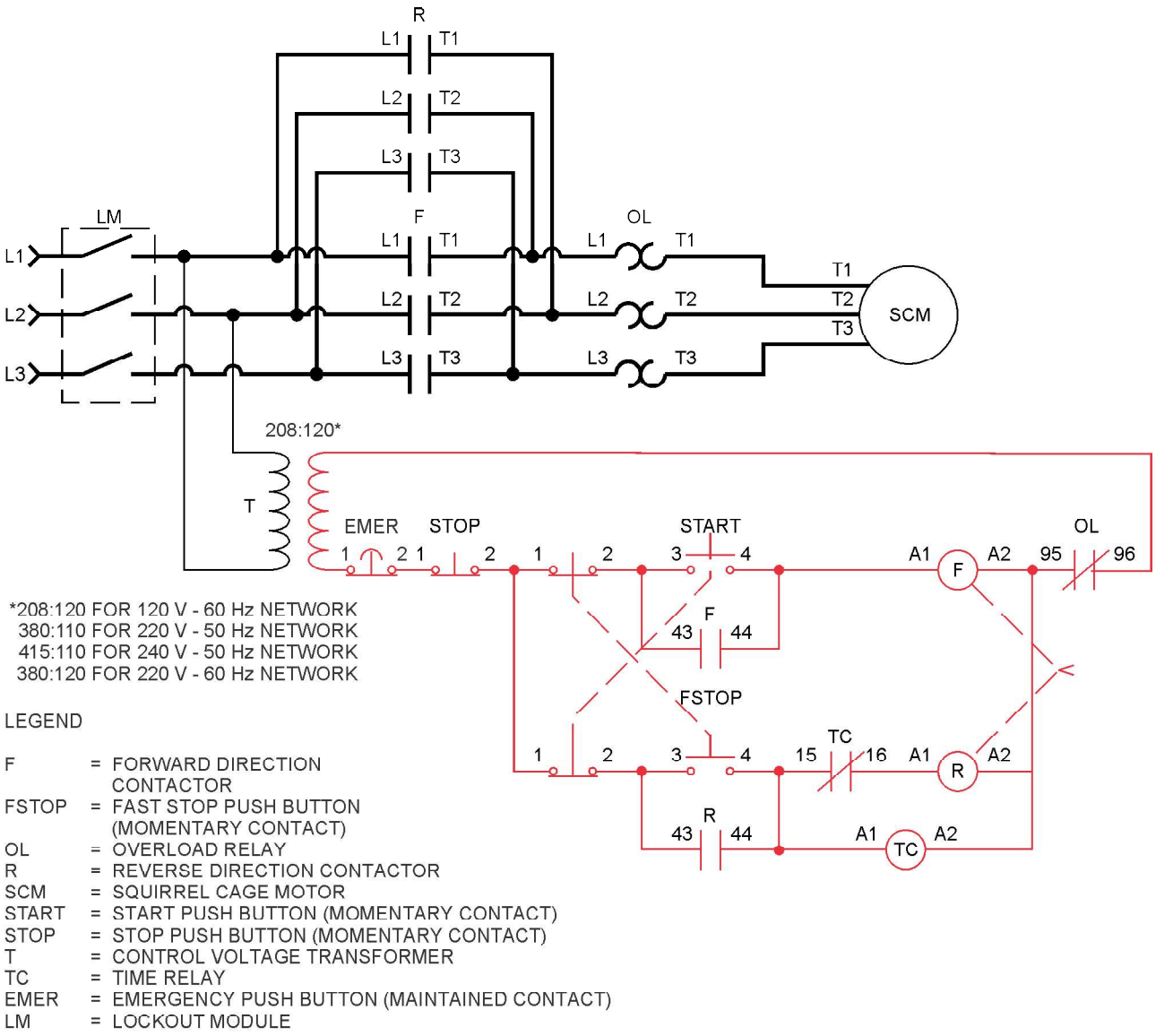

Figure 6-6. Plugging circuit with time relay.

PROCEDURE OUTLINE

The Procedure is divided into the following sections:

- Basic setup
- Manual plugging
- Plugging using a time relay

PROCEDURE

In the first part of this exercise, you will set up a reversing circuit that enables plugging. You will do plugging with the Inertia Wheel on the motor shaft and stop the circuit manually, before it rotates backwards. You will observe that it is difficult to stop the circuit on time, every time.

You will then plug a time relay and adjust the delay to make the motor stop perfectly, each time the FSTOP push button is pressed.

In the last part of the exercise, you will remove the Inertia Wheel and observe that the R contactor is now energized too long, making the motor rotate in the opposite direction.

⚠ WARNING

The AC Power Supply provides high voltages. Do not change any AC connection with the power on.

Basic setup

1. Perform the Basic Setup and Lockout/Tagout procedures.

Manual plugging

2. Install the Brake Motor, Inertia Wheel, and Safety Guard.

   Connect the circuit shown in Figure 6-6.

3. Manually disengage the friction brake.

   Connect a lead between the Time Relay terminals 15 and 16 to disable the Time Relay.

   Perform the Energizing procedure.

   Press the START push button to start the motor, and wait for the motor to rotate at full speed.

4. Press the FSTOP push button and, when the motor comes to a stop, press the STOP push button to de-energize the motor.

   Repeat the START - FSTOP - STOP sequence to measure the plugging time required to stop the motor.

   Plugging time:_____

   You should notice that it is not easy to manually stop the motor right on time, with consistency.

5. Turn off the Lockout Module.

   Disconnect the lead between the Time Relay terminals 15 and 16.

Plugging using a time relay

6. Set the Time Relay with the following parameter values:

- Function code: A (On-delay)
- Time-delay value: 1 s
- Time-delay adjustment: 20%

7. Turn on the Lockout Module.

Press the START push button to start the motor.

Press the FSTOP push button to start the plugging operation.

Does the motor keep on turning as the circuit is switched off by the Time Relay? If yes, does the motor turn in forward or reverse direction?

_____

_____

8. Is the time delay too long or too short?

❑ Too long ❑ Too short

9. Adjust the time delay to de-energize the motor exactly as it switches off. Repeat the START - FSTOP sequence as often as necessary.

Note the time delay value required to stop the motor exactly as it switches off.

Time delay value:_____

10. Perform the Lockout/Tagout procedure.

Remove the Inertia Wheel.

11. Perform the Energizing procedure.

Press the START push button.

Does the motor keep on turning, as the circuit is switched off by the Time Relay? If yes, does the motor turn in a forward or reverse direction?

_____

_____

12. Is the time delay too long or too short?

❑ Too long ❑ Too short

13. Why would this control circuit not be used with variable loads?

_____

_____

_____

14. Turn the individual power switch of the AC Power Supply off, disconnect the circuit, remove the magnetic labels, and return the equipment to the storage location.

CONCLUSION

A motor can be plugged with a time relay to make it stop rapidly and perfectly each time. If the motor is not stopped completely by the plugging, it is a sign that the time delay is too short. But if it turns in the opposite direction after stopping, the time delay is too long.

If the motor is connected to a variable load, using a time relay is not a good option; the time delay has to be readjusted upon every change in load to obtain perfect plugging stops. Plugging switches, which sense changes in motor speed, can be a good alternative to time relays under those circumstances. They are, however, more expensive.

REVIEW QUESTIONS

1. Which control device sees its NO and NC contacts states change following preset time delays?

   a. Plugging switch

   b. Time relay

   c. Contactor

   d. None of the answers above is correct.

2. In the Figure 6-6 circuit, what happens if time relay terminals 15 and 16 are short-circuited?

   a. The motor will only run in the reverse direction.

   b. The motor will only run in the forward direction.

   c. The motor will function in both directions.

   d. The motor will not turn at all.

3. In the Figure 6-6 circuit, what happens when the STOP push button is pressed while the motor is running in the forward direction?

   a. Two line phases are inverted to make the motor stop rapidly.

   b. The motor slows down until it stops.

   c. The friction brake is automatically applied.

   d. None of the answers above are correct.

4. In the Figure 6-6 circuit, how can you keep the time relay well set, if the load increases significantly?

   a. Increasing the time delay.

   b. Changing the time relay function code.

   c. Shortening the time delay.

   d. Increasing the overload relay current setting.

5. What is the meaning of this symbol: 

   a. NC contact with time delay opening.

   b. NC contact with time delay closing.

   c. NO contact with time delay opening.

   d. NO contact with time delay closing.

Primary Resistor Starters with Time Relays

EXERCISE OBJECTIVE

Understand how a time relay can be used jointly with primary resistor starters.

DISCUSSION

Primary resistor starters are used to reduce the voltage to the motor upon starting, causing starting torque and current to diminish. When the motor is started, a voltage drop is produced by resistors placed in series with the motor terminals. Resistors are bypassed after a while to make the motor run under full voltage and avoid heat dissipation through the resistors.

In Exercise 5-1, you completed such a circuit in which you bypassed the resistors using a selector switch and a contactor. But it is also possible to automatically bypass the resistors by using a time relay. This enables the resistors to be switched off at an appropriate time and prevents the resistors from being left on inadvertently.

Figure 6-7 is a primary resistor circuit using a time relay. Once the power and the Manual Starter are turned on, the motor is started under reduced voltage, because resistors are placed in series with its terminals. The Time Relay coil is also energized and the on delay starts. Once the preset delay has been reached, the Time Relay NO contact closes. This energizes the running contactor, hence bypassing the resistors and making the motor run under full voltage.

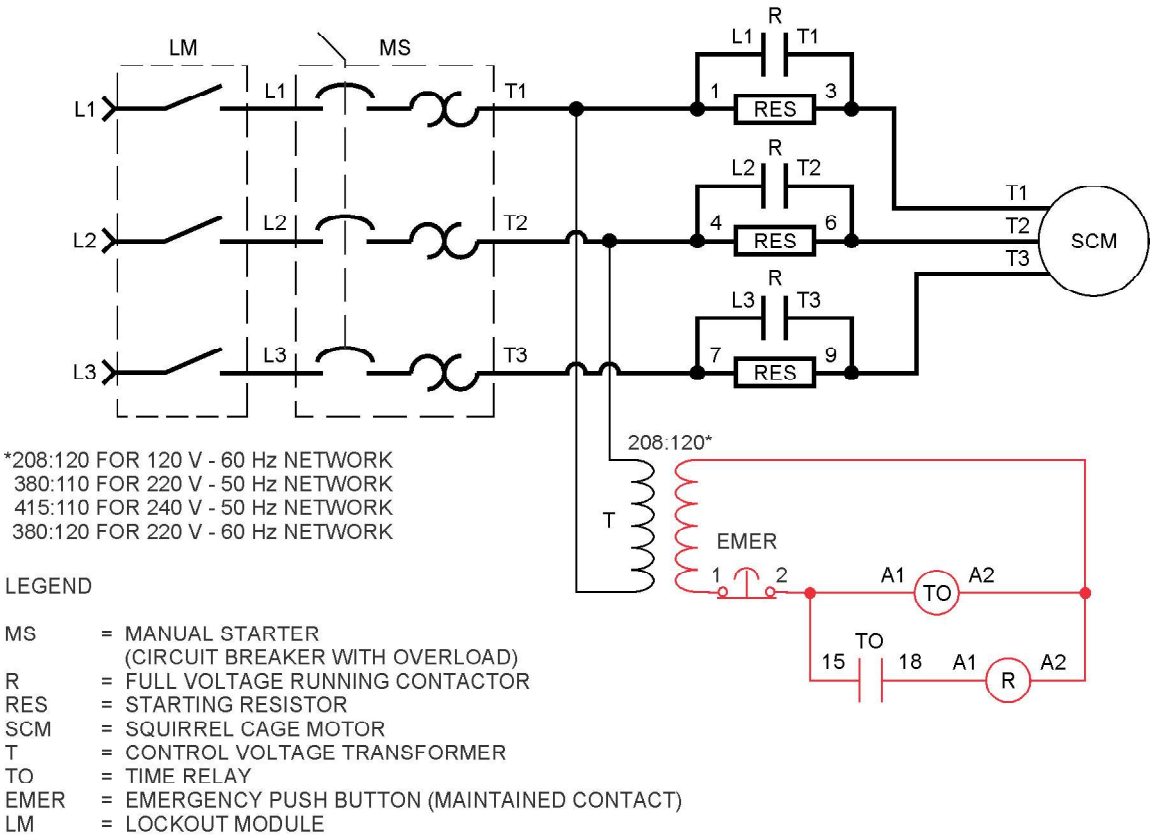

Figure 6-7. Primary resistor starter with time relay circuit.

PROCEDURE OUTLINE

The Procedure is divided into the following sections:

- Basic setup
- Primary resistor starter with time relay circuit

PROCEDURE

In this exercise, you will put together a primary resistor starter circuit and the Time Relay module. This setup will utilize the On-delay function of the Time Relay to delay the actuation of a contactor that bypasses the resistors. You will modify the delay time to see the influence it has on motor acceleration.

⚠ WARNING

The AC Power Supply provides high voltages. Do not change any AC connection with the power on.

Basic setup

1. Perform the Basic Setup and Lockout/Tagout procedures.

Primary resistor starter with time relay circuit

2. Install the Brake Motor, Inertia Wheel, and Safety Guard.

   Connect the circuit shown in Figure 6-7.

   Resistors must be connected by their extremities and not by the intermediate taps, in order to obtain maximum resistance.

3. Manually disengage the friction brake.

   Set the knob of the Manual Starter to the O position.

   Set the Time Relay with the following parameter values:

   - Function code: A (On-delay)
   - Time-delay value: 1 s
   - Time-delay adjustment: 50%

4. Perform the Energizing procedure.

   Set the knob of the Manual Starter to the I position.

   Does the motor acceleration increase when the contactor is energized (after 0.5 s)?

   ❑ Yes ❑ No

5. Set the knob of the Manual Starter to the O position.

   Set the time delay value to 10 s.

   Set the knob of the Manual Starter to the I position.

   Does the motor acceleration increase when the contactor is energized (after 5 s)?

   ❑ Yes ❑ No

⚠ CAUTION

The Starting Resistors module may be hot. Please be careful when you handle this module after use.

6. Turn the individual power switch of the AC Power Supply off, disconnect the circuit, remove the magnetic labels, and return the equipment to the storage location.

CONCLUSION

Primary resistor starters are used to start motors at a lower voltage, produced by resistors inserted in series with motor terminals. After a time delay, starting resistors are bypassed to let motors operate at full line voltage. This bypass procedure can be controlled manually by an operator, or automatically, with the help of a time relay.

REVIEW QUESTIONS

1. In the Figure 6-7 circuit, when does the motor receive full voltage?

   a. As soon as power is applied to the system.

   b. As the R contactor energizes.

   c. As the Manual Starter turns on.

   d. As the Manual Starter turns off.

2. What is the meaning of this symbol: 

   a. NC contact with time delay opening.

   b. NC contact with time delay closing.

   c. NO contact with time delay opening.

   d. NO contact with time delay closing.

3. In the Figure 6-7 circuit, when is the Time Relay coil energized?

   a. As soon as power is applied to the system.

   b. As the motor approaches its nominal speed.

   c. As the Manual Starter turns on.

   d. As the Manual Starter turns off.

4. In the Figure 6-7 circuit, which control device is used to switch the R contactor on and off?

   a. Control relay

   b. Time relay

   c. Plugging switch

   d. Rheostat

5. In the Figure 6-7 circuit, what happens to the R contactor, if the Manual Starter is turned off while the motor is running at full voltage?

   a. The R contactor NO contact opens immediately.

   b. The R contactor NO contact opens after a time delay.

   c. The R contactor stays actuated.

   d. None of the answers above is correct.

Unit Test

1. Which time function of the Time Relay, Model 3132, causes its NO contact to alternately close and open at a given rate?

   a. Flashing (code D)
   b. On- and off- delay (code C)
   c. Off-delay (code B)
   d. On-delay (code A)

2. Which time relay type involves air or liquid going through a valve?

   a. Dashpot
   b. Synchronous clock
   c. Solid-state
   d. Programmable

3. Which time relay type contains electronic devices, but is not a PLC?

   a. Dashpot
   b. Synchronous clock
   c. Solid-state
   d. Programmable

4. Which time function of the Time Relay, Model 3132, causes the starting signal to be delayed, but not the stop signal?

   a. Rising edge pulse (code E)
   b. On- and off- delay (code C)
   c. Off-delay (code B)
   d. On-delay (code A)

5. How do plugging circuits create the counter torque necessary to stop a motor?

   a. By sending DC current to the stator.
   b. By using a friction brake.
   c. By reversing two power lines.
   d. None of the answers above is correct.

6. When can a time relay be useful in plugging applications?

   a. When the motor stop time is known and variable.
   b. When the motor stop time is unknown and stable.
   c. When the motor stop time is known and stable.
   d. When the motor stop time is unknown and variable.

7. In plugging circuits with a time relay, what happens if the time delay is set too long?

   a. The motor does not stop completely.
   b. The motor stops and turns in reverse direction.
   c. A short-circuit occurs.
   d. None of the answers above is correct.

8. What is the purpose of a time relay in a primary resistor circuit?

   a. Delay the action of friction brakes.
   b. Bypass the starting resistors after starting.
   c. Add resistors to the circuit after starting.
   d. None of the answers above is correct.

9. What is the effect of a reduced voltage on motor torque?

   a. No effect on motor torque.
   b. Decreased motor torque.
   c. Increased motor torque.

10. Why are starting resistors bypassed?

    a. To avoid heat dissipation.
    b. To make the motor run under full voltage.
    c. Both the answers above are correct.
    d. None of the answers above is correct.