PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA

MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

NOUR BACHIR UNIVERSITY CENTER EL BAYADH

Institute of Technology

Electrical Engineering Department

3rd YEAR OF BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING

PRACTICAL TASK

Electrical schematics and Electrical Switchgear

Directed by:

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Teaching objectives:

This subject covers the design of simple electrical assemblies: analysis, operating principles, schematic diagrams of electrical circuits for all types of controls, as well as the sizing of electrical equipment. It also enables students to put into practice the knowledge acquired during their training by c r e a t i n g electrical circuits and applying them to lighting circuits and electric motor controls.

Recommended prior knowledge

Electrical equipment technology and Electrical measurements.

Instructions and safety information

- Students should only work on the fixtures under the supervision of their teachers.
- Observe the information given in the data sheets for the individual components, in particular all safety instructions!
- Only make electrical connections and disconnections when there is no voltage!
- Use only cables with safety connectors for electrical connections.
- When disconnecting connecting cables, pull only on the safety connector, not on the cable.
- Measure the resistance of the laboratory earth connection and ensure that it complies with the recommended standards.
- Install the PE connection cable (yellow-green) first, before making any connections.

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Practical task :

Practical task 1: The main lighting fixtures

Practical task 2: Manual control of one and two contactors

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Practical Task 4: Starting a two-phase induction motor

Practical task 5: Star/delta starting of an induction motor

Practical task 1: The main lighting fixtures

Pedagogical objectives

- Test pushb uttons, circuit-breakers and fuses in energized and de-energized states.
- Understand the structure and operation of a pushbutton.
- Know the difference between a push-button and a switch.
- Know the difference between a normally open (NO) contact and a normally closed (NC) contact.
- Create basic logic circuits using electrical diagrams with contacts and switches.
- Socket installation, single-circuit installation, double-circuit installation, ON/OFF installation, remote switch installation, timer installation.
- Master the operating diagram.

Equipment and materials used

- FESTO traffic sign
- 24V FESTO power supply
- Universal multimeter
- Connection cables with safety connectors

1. **Identification and testing of each experimental panel component** Either the experimental panel used

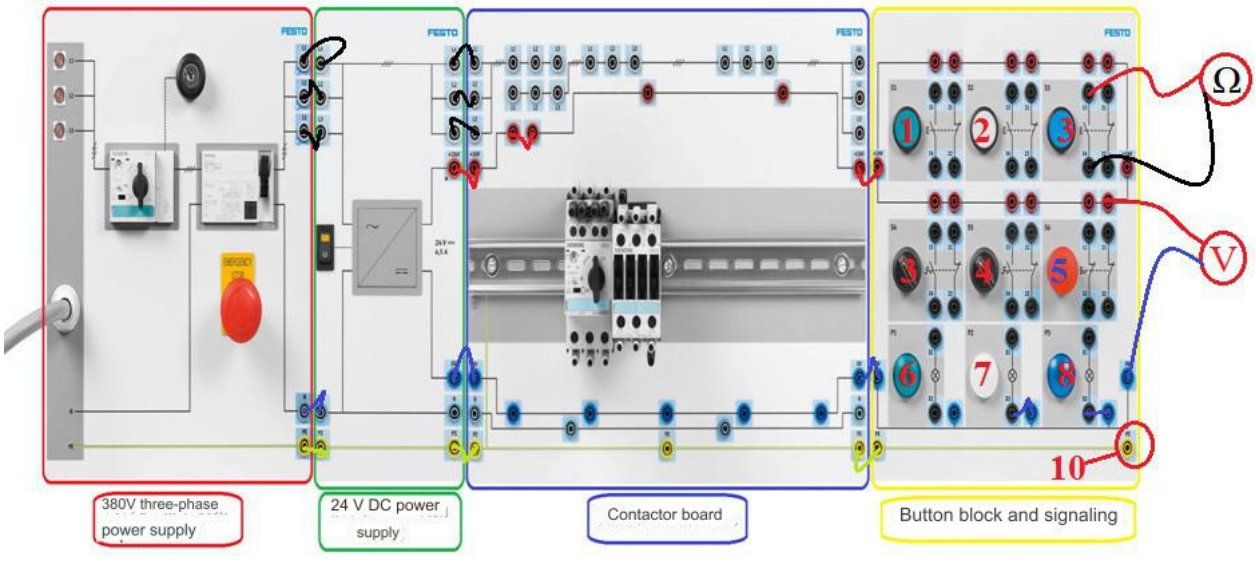


Figure 1: FESTO experimental panel

Table 1:

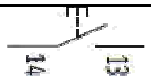
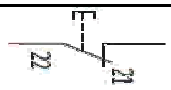
Component	1	2	3	4	5	6
Name	Button pushbutton					
Designation	S1					
Symbol NO Indication Ohmeter	 ...infinite..					
Symbol NF Indication Ohmeter	 .....Zero.....					
NO terminal marker	13-------14					
NC terminal marker	21--------22					

Table 2:

Component	7	8	9	10
Name				
Designation				
Terminal markers				

Table 3:

Designation	K	KM	Q	P	M
Name					

Activity 1:

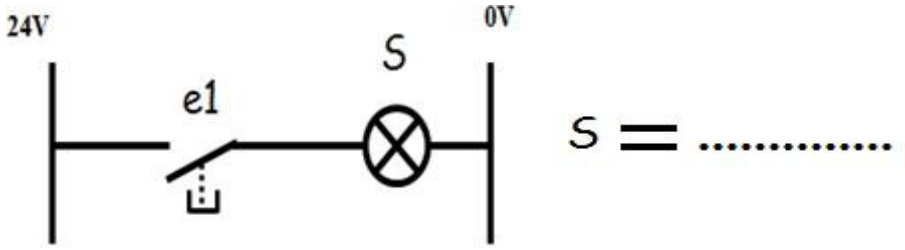
1. Explain the operating principle of each component in the table above.
2. If you have several components with the same designation in an electrical circuit, how can you tell them apart? For example, several switches?
3. We want to create a circuit to control several locations (e.g. 3 locations) of a doorbell with 220V AC voltage and protection. Propose a circuit using the symbols shown in the appendix.

Note: Component designations shown in the diagrams are based on EN 61346-2. Letters are assigned according to the component.

2. Implement basic universal logic functions using the components in experimental panel of Figure 1.

2.1 The equation S = e1

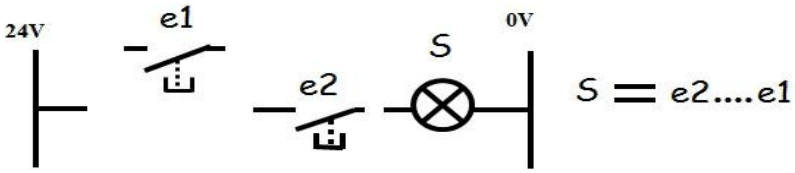
Complete the diagram, the truth table and give the equation S?



e1	S

2.2 The **OR** function

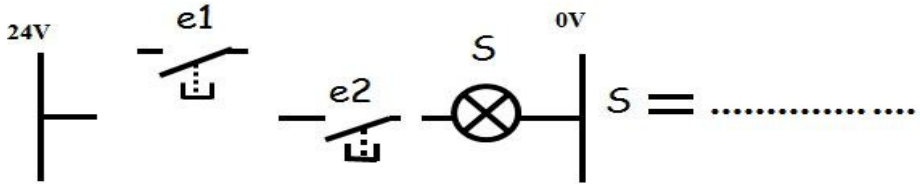
Complete the diagram, the truth table to give the equation (e1 **OR** e2)?



e2	e1	S
0	0	
0	1	
1	0	
1	1	

2.3 The **AND** function

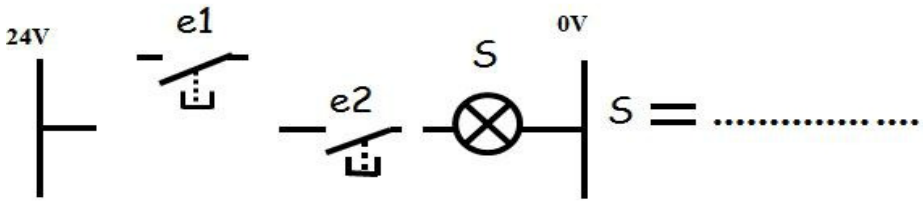
Complete the diagram and truth table for the equation (e1 AND e2)?



e2	e1	S
0	0	
0	1	
1	0	
1	1	

2.4 The **XOR** function

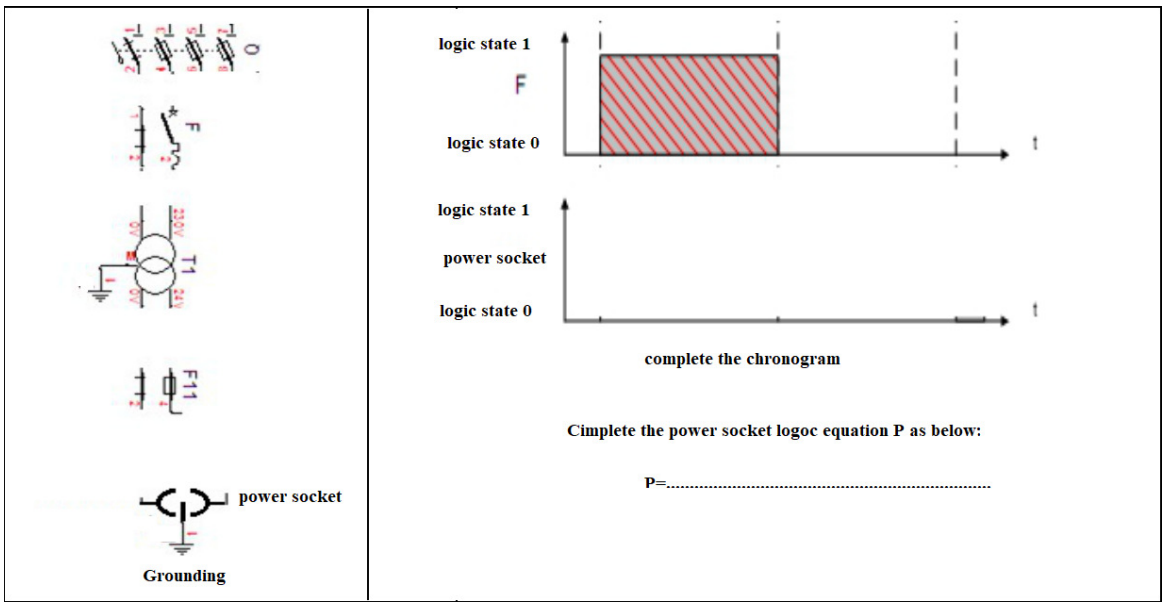
Complete the diagram and truth table for the equation (e1 XOR e2)



e2	e1	S
0	0	
0	1	
1	0	
1	1	

4. Create basic electrical circuits using of the components of the experimental panel shown in figure 1. 3.1

5. Socket mounting

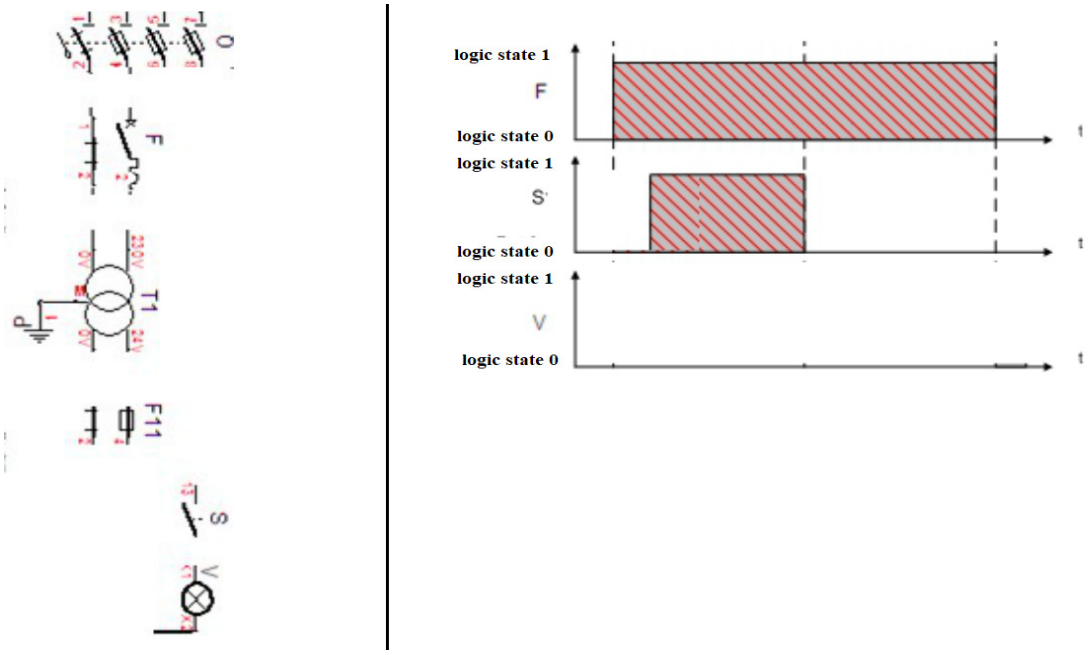


Activity 2:

a- Complete the diagram, the chronogram and the equation Prise as a function of F and F11?

b- Make the circuit on the experimental panel (figure 1).

3.2 Single-ignition assembly



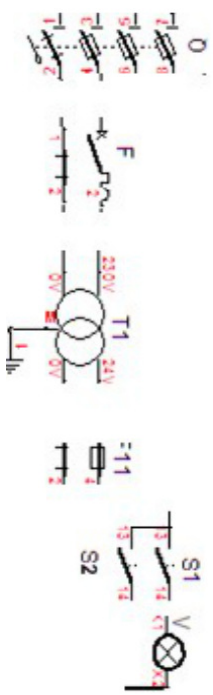
V=.....

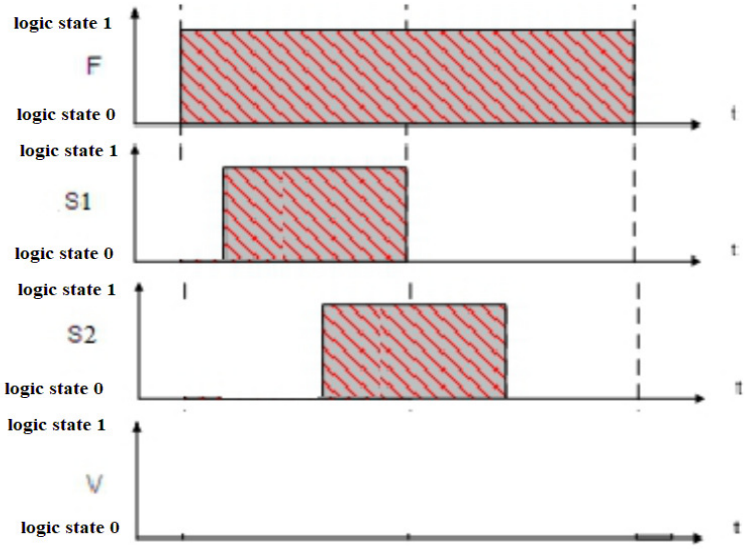
Activity 3:

a- Complete the diagram, the chronogram and the equation V as a function of F, F11 and S?

b- Make the circuit on the experimental panel (Figure 1).

3.3 Dual ignition assembly





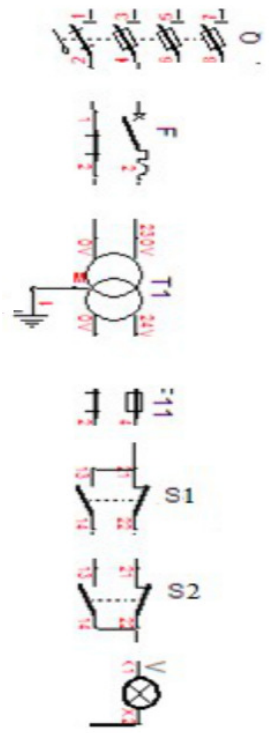
V=.....

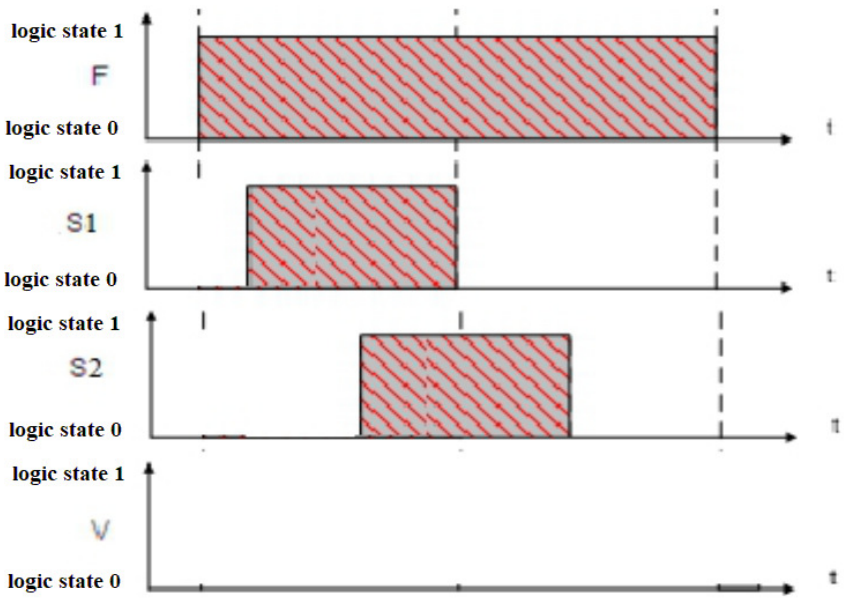
Activity 4:

a- Complete the diagram, the chronogram and the equation V as a function of F, F11, S1 and S2?

b- Make the circuit on the traffic sign (figure 1).

3.4 Two-way mounting





Chronogram

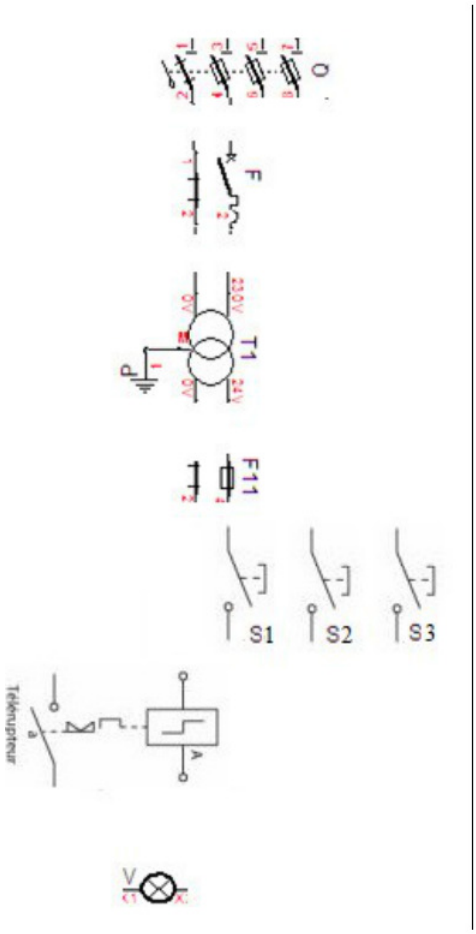
V=.....

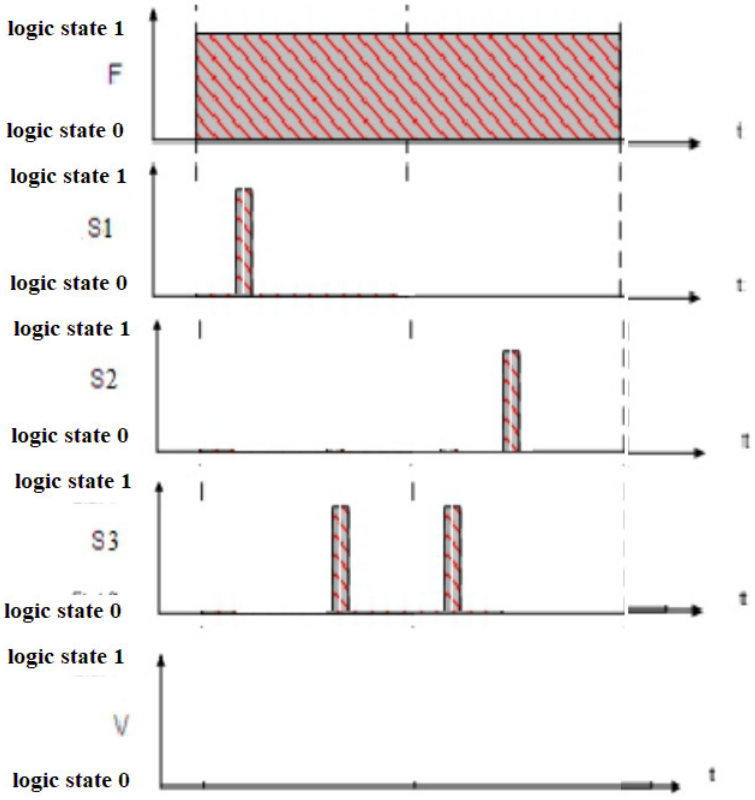
Activity 5:

a- Complete the diagram, the chronogram and the equation V as a function of F, F11, S1 and S2?

b- Make the circuit on the traffic sign (figure 1).

3.5 Remote switch mounting





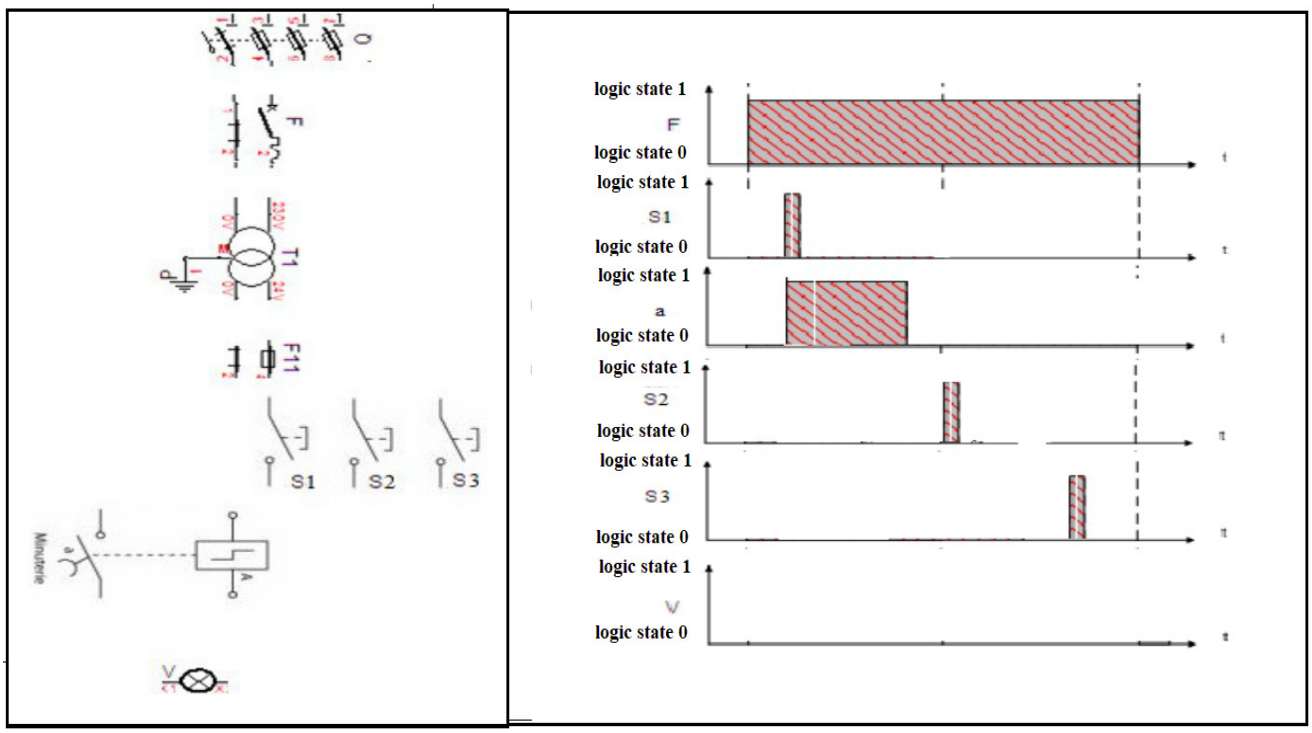
V=.....

Activity 6:

a- Complete the diagram, the chronogram and the equation V as a function of F, F11, S1 and S2?

b- Make the circuit on the signpost (Figure 1).

3.6 Installation with timer



V=.....

Activity 7:

a- Complete the diagram, the chronogram and the equation V as a function of F, F11, S1 and S2?

b- Make the circuit on the signpost (Figure 1).

Practical task 2: Manual control of one and two contactors :

The teaching objectives of PRACTICAL TASK2 are :

- Know the structure of a contactor.
- Know the difference between push-button control and a switch.
- Know the various accessories associated with contactors, such as auxiliary contactors and timed relays.
- Know the principles of contactor interlocking: mechanical interlocking and electrical interlocking.
- Master the operating diagram.

1. Reminders

1.1 Introduction

The contactor is a control device capable of establishing or interrupting the flow of electrical energy to power high-power industrial motors (over 50 kW) and, in general, high-power consumers. It performs the switching function. It is capable of establishing, supporting and interrupting currents under normal circuit conditions, including overload conditions during operation. The contactor's advantage is that it can be controlled remotely. It belongs to the family of pre-actuators, since it comes before the actuator in the energy chain. A contactor can be operated by any element of the control circuit (push-button, sensor, etc.).

It is also used in the home to power electrical appliances such as heaters and water heaters, as the control devices (thermostat, timer switch and other control contacts) could be quickly damaged by the excessive current.

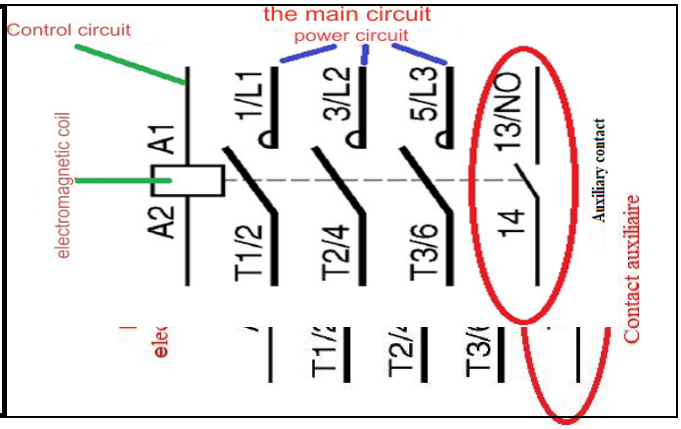
2. Constitution

2.1 The power circuit

This is a set of parts that conduct the contactor's main current. It consists of : Labeled main contacts (1/L1- T1/2, 3/L2-T2/4, 5/L3-T3/6)

The power contactor comprises 4 functional assemblies:

- the main or power circuit
- the control circuit
- the electromagnet
- auxiliary circuit (additional block)



2.2 The control and signalling circuit

It includes one, two or four control contacts for, for example, **self-holding, warning lights**....

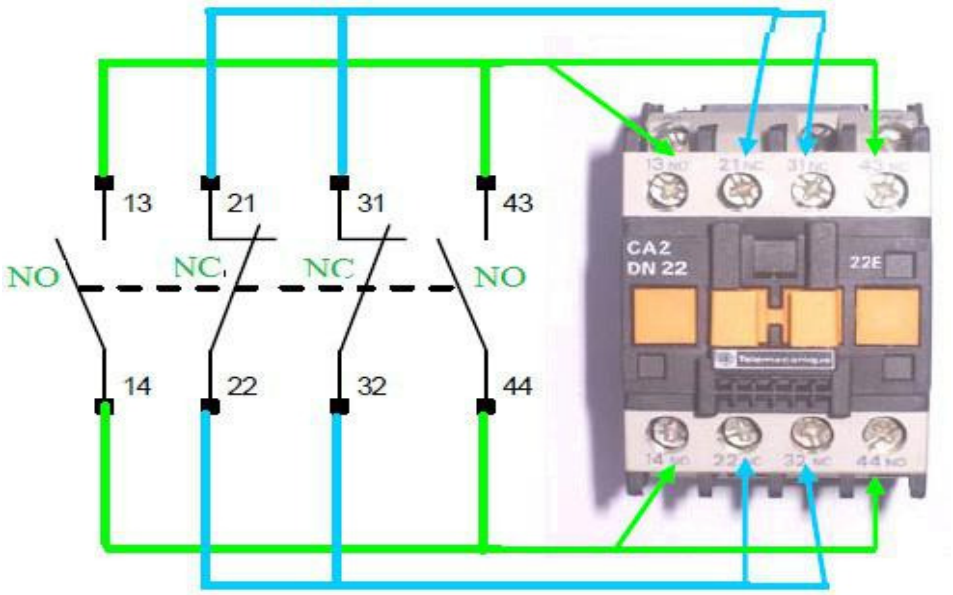


Figure 2: Télémécanique contactor control contacts

2.3. Auxiliary contact block

The auxiliary contact block is a mechanical connecting device that fits onto contactors. It allows 2 to 4 additional contacts to be added to the contactor. The contacts are designed for use in the control section of circuits. They have the same designation and marking in the diagrams as the contactor on which they are installed (KA, KM...).

The auxiliary circuit is created by adding an auxiliary block, and is designed to perform other functions:

- Add additional contacts, time delay.

Its main features are instantaneous and timed auxiliary contacts. They can be installed on the face.

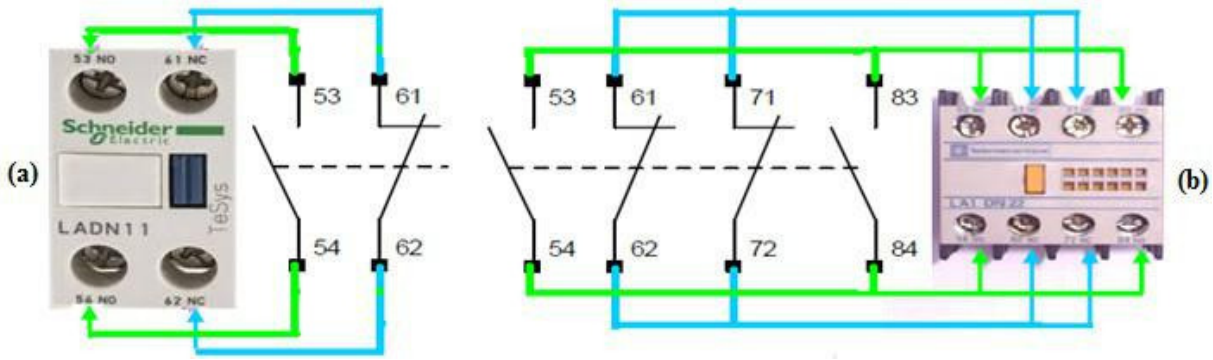


Figure 4 : Auxiliary contact block

(a) bipolar and (b) tetra-polar

2. 4 The driving force

The electromagnet is the element that attracts the power and control circuit contacts and the auxiliary circuit block simultaneously. It comprises :

- a coil supplied with AC or DC voltage at 24V; 48V; 110V; 230V; 400 V. It is identified by terminals A1, A2.

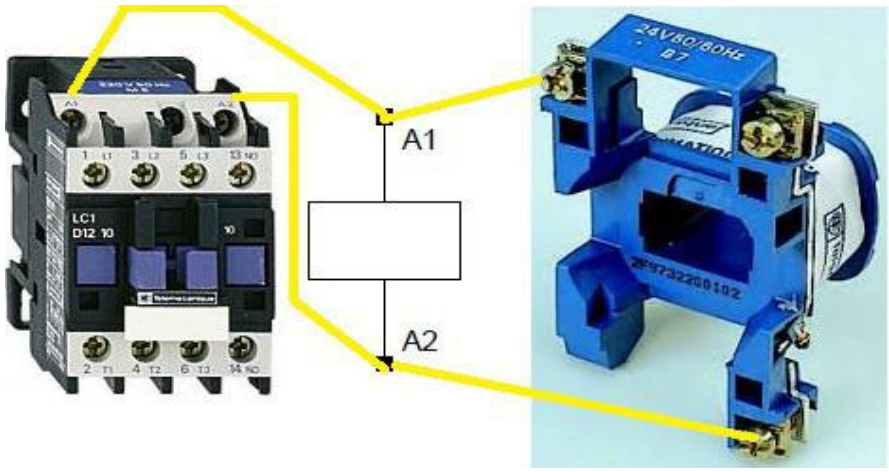
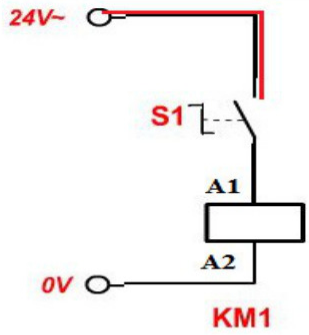


Figure 5: contactor coil

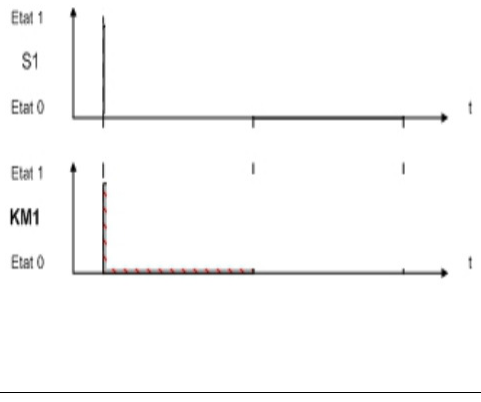
2.5 Control circuit principle

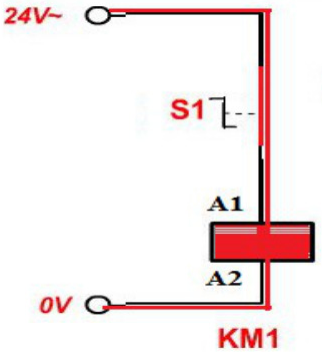
2.5.1 Controlling a contactor using a changeover switch

The switch has two permanent positions, either open or closed.

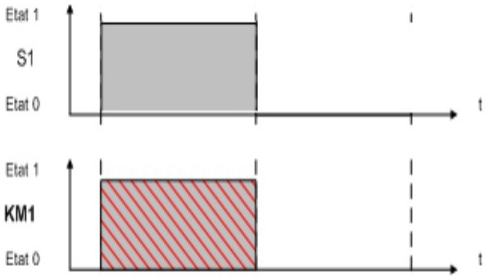


Resting state



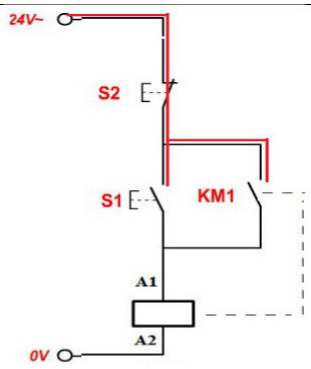


S1 activated

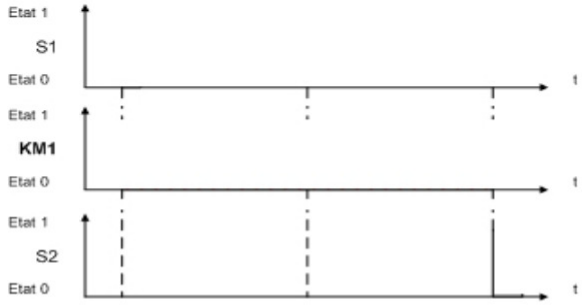


2.5.2 Control of a contactor via a BP pushbutton (self-holding circuit)

The push-button has two positions, one permanent, the other fleeting (or momentary).

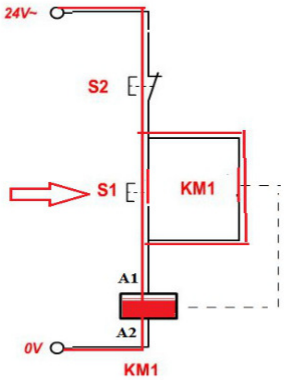


Resting state

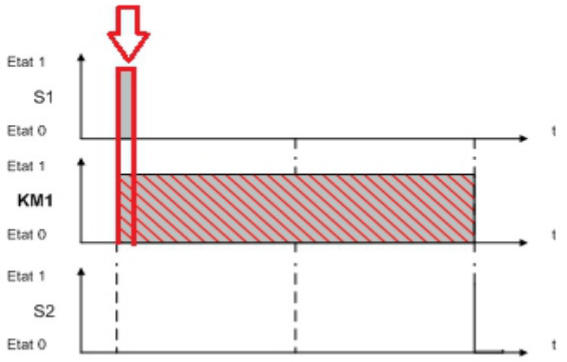


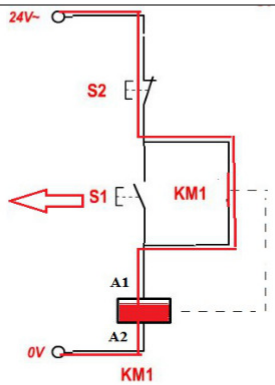
Chronogram

KM1= ⁄(S1+KM1)

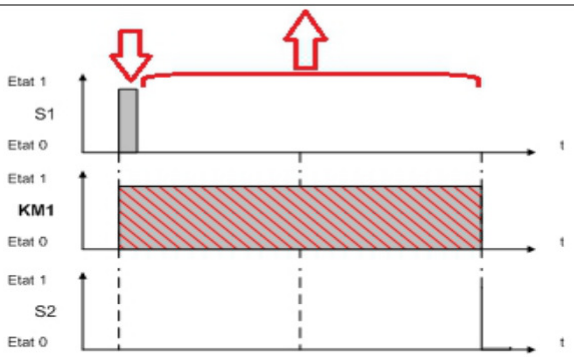


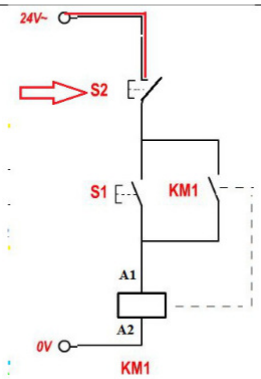
Press S1



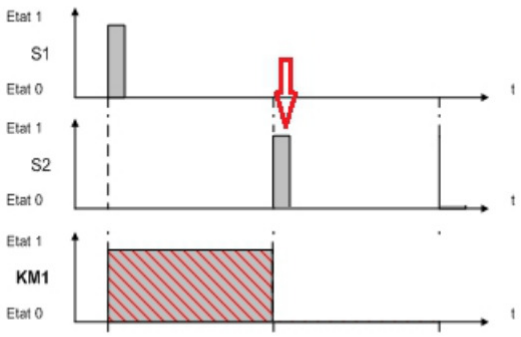


S1 release



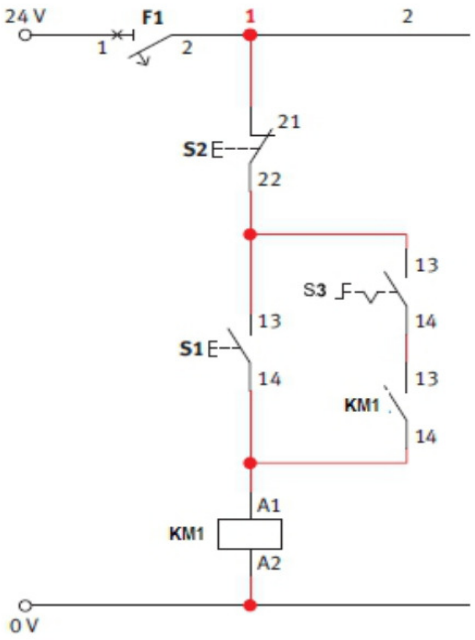


Press S2

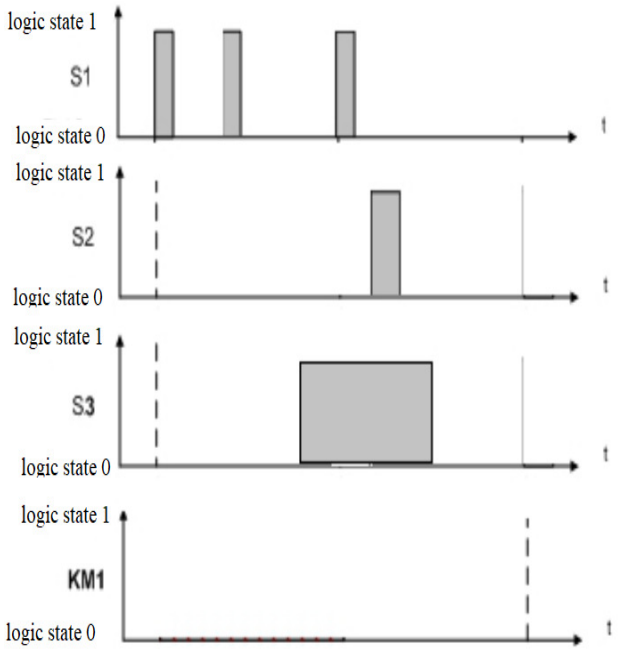


2.5.3 Control using a combination of self-holding circuit and stepping mode

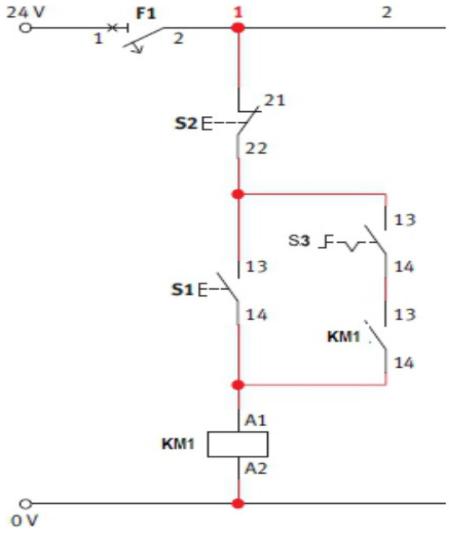
Optional stepping mode added to self-holding controller



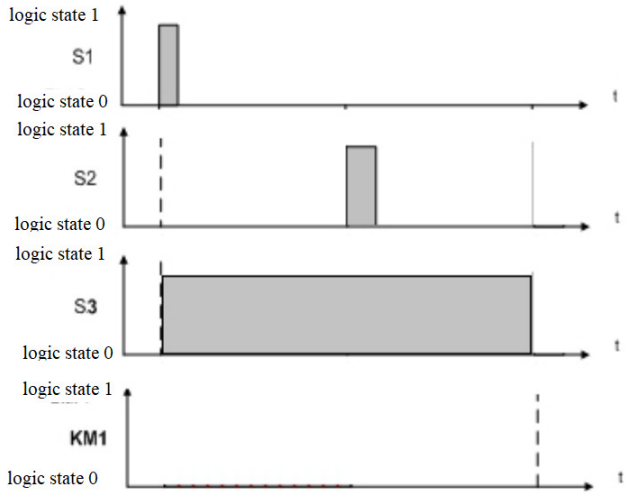
Step-by-step mode (S3 not actuated)



KM1=.....



Combination of self-holding circuit and step-by-step mode
(S3 activated)



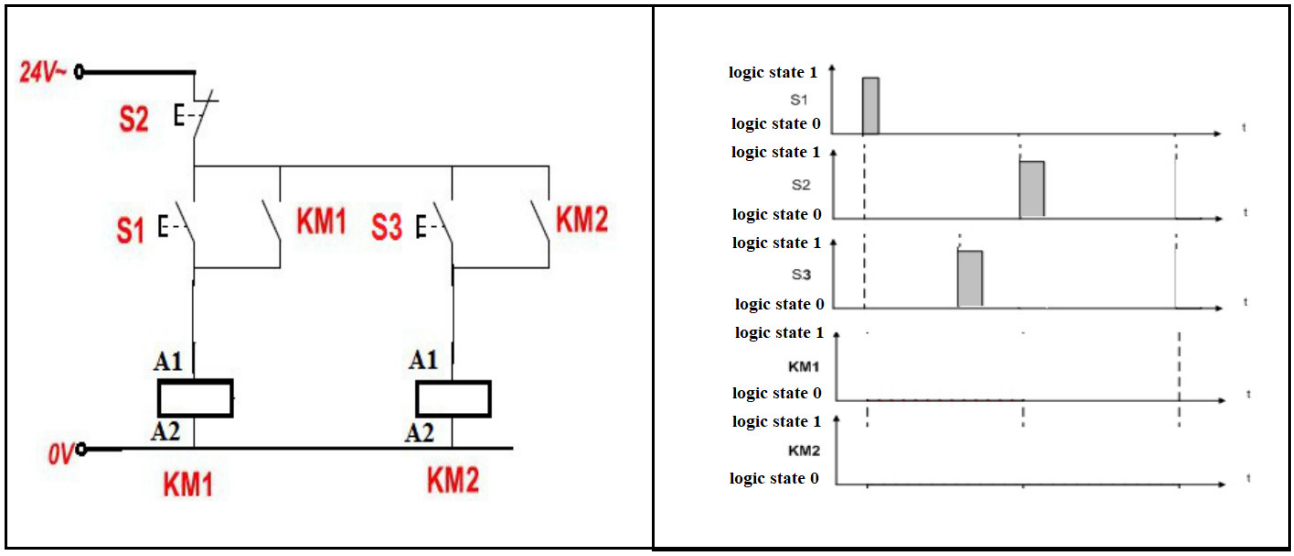
KM1=.....

Activity 1:

- Complete the chronogram and equation KM1

2.5.4 Control of two contactors using BP pushbuttons

To control two contactors, we propose to study the following circuit:



Activity 2:

- Complete the timelines, respecting the actions on the POs (S1, S2 and S3)?
- Can contactors KM1 and KM2 be activated simultaneously? Define the period on the chronogram?
- What do you suggest to avoid simultaneous activation of both contactors?

2.5.5 Electric lock

It prevents the coils of two contactors from being energized at the same time. Example: reversing switch for a three-phase induction motor. Closing both contactors at the same time would cause a short-circuit between phases.

2.5.6 Mechanical lock

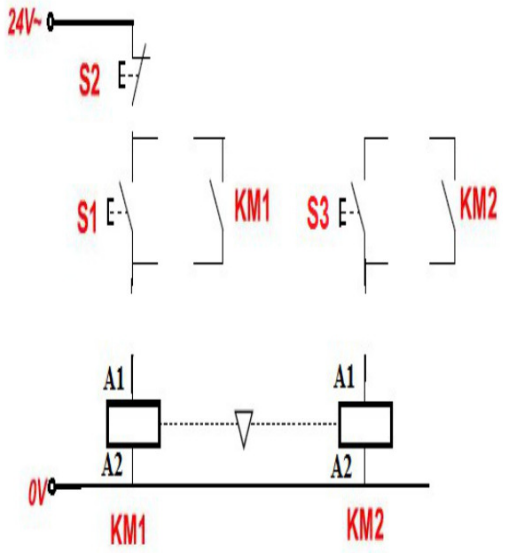
This device mechanically prevents the simultaneous switching of two adjacent contactors. It is sometimes fitted with contacts to achieve the electrical safety described above. The contactors are mechanically linked and cannot engage simultaneously. This device is safer than the previous one. The two devices are often combined to guarantee maximum safety.

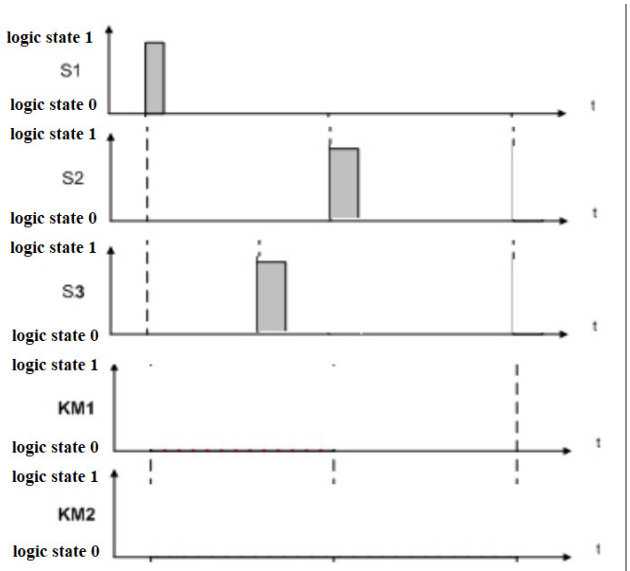
Figure 6: Mechanical interlock of two power contactors

3. Manipulating and building the circuit

Equipment and materials used (see Figure 1)

FESTO experimental panel l 24V FESTO power supply Universal multimeter 2xSiemens 24V contactor Mechanical lock.





KM1=.....

KM2=.....

Activity 3:

- Complete the control diagram for two contactors by inserting the electrical interlock?
- Complete the timeline corresponding to this diagram, taking into account actions S1, S2 and S3?
- Give the control diagram by inserting an emergency stop?
- Give a conclusion?

Practical Task 3: Starting a three-phase cage induction motor in one direction only

The teaching objectives of PRACTICAL TASK3 are :

- Identify the nameplate of an induction motor.
- Understand the structure of electrical protection devices: thermal relays and thermal-magnetic circuit breakers.
- Start-up of a 0.7 kW three-phase induction motor.
- Master the operating diagram.

1. Reminders

1.1 Introduction

The asynchronous induction motor is the basic motor of today's industry, thanks to its simplicity of operation, ease of maintenance and lower cost than other types of motor. It is particularly suitable for constant-speed drives. Its starting speed is linked to the overcurrent admissible by t h e electrical installation at torque

required for the driven machine, and the permissible start-up time.

The engine starting device must meet the following requirements:

1.2 Mechanical requirements

the motor must be able to start: the starting torque Td must overcome the resistive torque Tr of the load to be driven: Td > Tr.

Acceleration conditions must be compatible with the load (e.g. escalator).

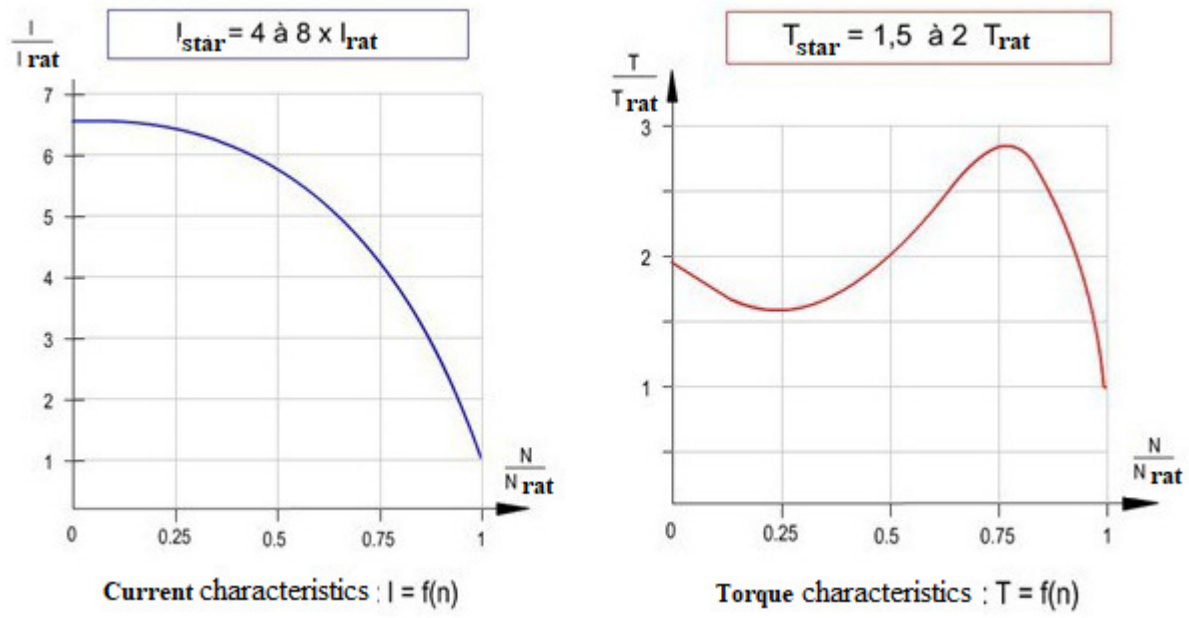


Figure 7: Curves showing current and torque characteristics as a function of induction motor speed

The relationships linking the motor characteristics at rated voltage with the characteristics at reduced voltage are : I'd/In = Id/Tn x Ud/Un

T'd/In = Td/Tn x U'd/Un2

- In: rating current
- Id: starting current at Un
- Un: rating voltage
- Tn: rating torque
- Td: starting torque at Un
- I'd: starting current at U'n
- U'd: reduced voltage on start-up
- T'd: starting torque at U'd

1.3 Electrical requirements

The starting current Id can be 4 to 8 times the rated current In. This The starting current must therefore be compatible with the motor supply line.

Voltage drop on start-up must not exceed 10%.

The starting current must not cause the protection devices to trip.

The curve onfigure illustrates that the starting current of an asynchronous motor is very high.

To reduce the current peak at start-up, reduce the supply voltage.

However, this voltage reduction results in lower starting torque.

Any starting system must limit the current absorbed by the motor while respecting t h e mechanical performance of the motor + load assembly.

Direct starting is the simplest form of starting, and can only be carried out with squirrel-cage induction motors. The stator windings are coupled directly to the mains supply.

The following functions must be ensured for a correct engine start:

- Isolating is the role of the disconnector.
- Protect the power supply against short-circuits by using aM-type fuse cartridges.
- The role of the contactor is to control the flow of energy to the motor.
- Protect the motor against overloads, a function performed by the thermal relay.

1.4 Electrical motor overload protection

A motor is overloaded when the current flowing through it is too high, i.e. if the power required from the motor exceeds the rated power indicated by the manufacturer on the motor nameplate.

Depending on the level of protection required and the motor's operating conditions, this protection can be provided by :

- Thermal relays
- Thermal-magnetic circuit breakers
- Relays with thermistor probes
- Overcurrent relays
- Electronic relays with optional or integrated additional protections

Thermal relays and circuit-breakers are the most common means of protecting motors against low and prolonged overloads.

They are set at rated current In.

1.5 Thermal relay

The thermal relay is a device that protects the downstream receiver from overloads and phase interruptions. It does this by constantly monitoring the current in the load. In the event of an overload, the thermal relay does not act directly on the power circuit. A thermal relay contact opens the control circuit of a contactor, which cuts off the current to the load.

The thermal relay has no switching capacity, and is always associated with a contactor. The thermal relay cuts the power supply to the contactor in the control section via an auxiliary contact.

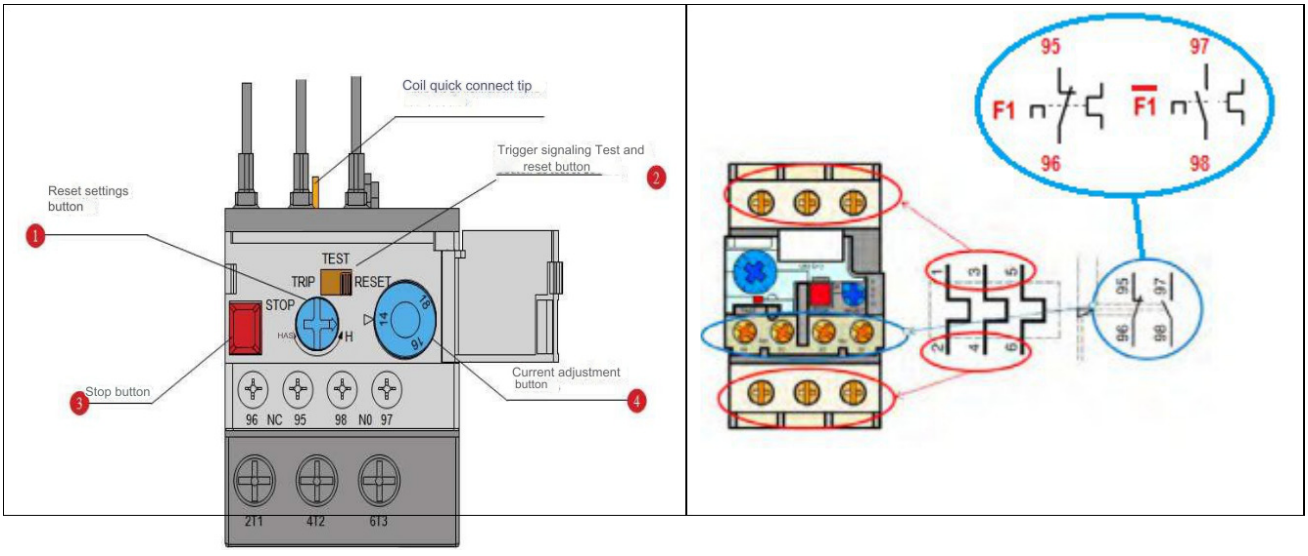


Figure 8: Thermal relay design

1.6 Thermal magneto circuit breaker

A motor circuit breaker is a magnetothermal device whose function is to interrupt the electric current in the event of an overload or short-circuit.

A- Thermal protection :

Each motor phase is protected by a bimetallic strip (thermal trip device) which, in the event of prolonged overcurrent, heats up by Joule effect and triggers a mechanism which opens the contacts. The tripping threshold can be set directly on the motor circuit-breaker.

B- Magnetic protection:

A trip unit fitted with an electromagnet protects each phase and, in the event of a short-circuit, cuts off the electric current. This trip unit is based on the creation of an instantaneous magnetic field (0.1sec) which activates a moving part and commands the contacts to open.

The magnetic part of the motor circuit breaker is not adjustable; it is the tripping curves that define the tripping threshold, expressed as a number of times the rated current (3 to 15 In).

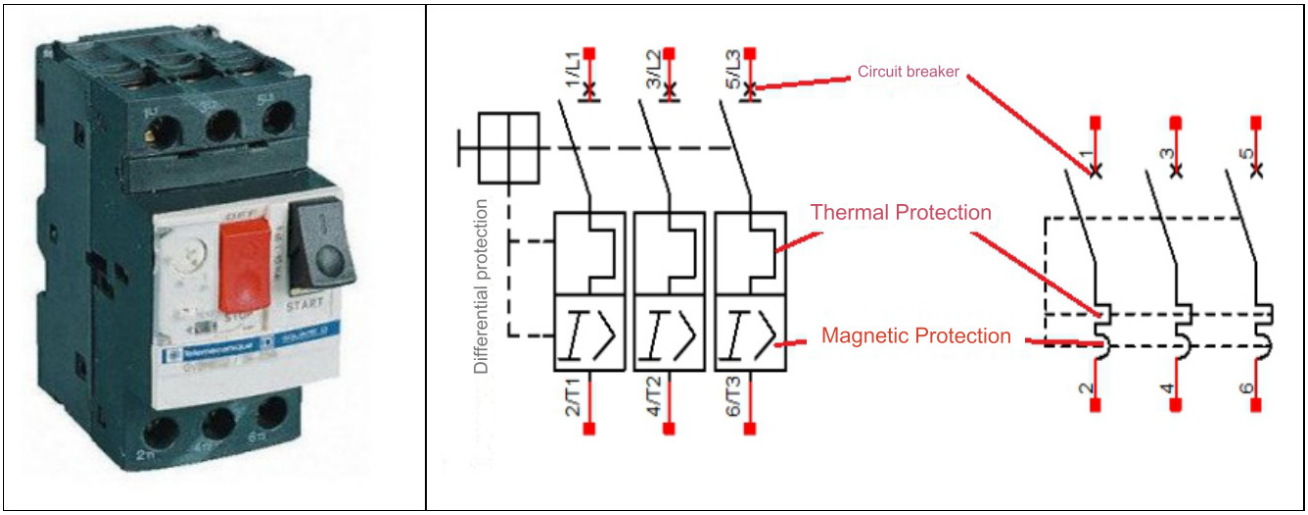


Figure 9: Design of a thermal-magnetic circuit breaker

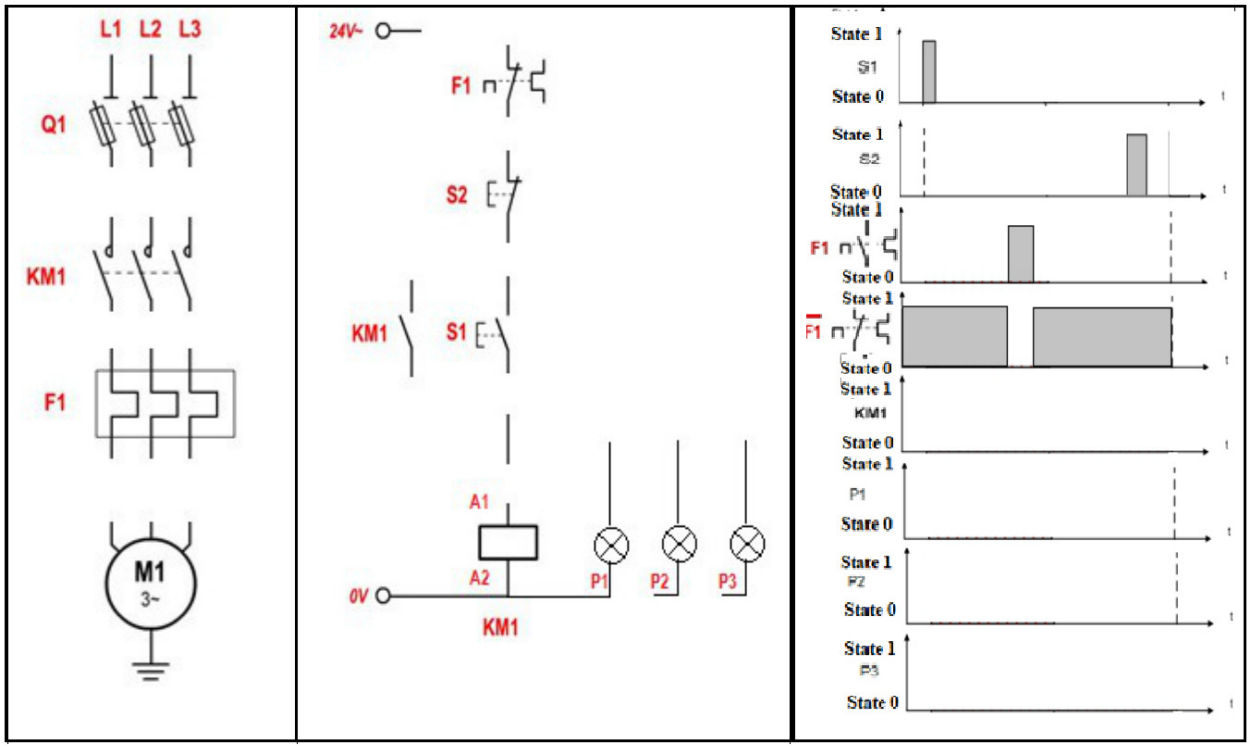
2. Handling

2.1 Equipment and materials used (see Figure 1)

- FESTO experimental panel
- 24V FESTO power supply
- Universal multimeter
- Siemens 24V contactor
- Thermal relay
- 0.7kW three-phase motor

2.2 Editing and production

Consider the following control and power diagram for a three-phase motor:



KM1=.....

P1: power-on indicator light.
P2: Indicates start- up.
P3: Indicates overload fault.

Activity :

1- Complete the diagram above and the corresponding chronogram?
2- Make the circuit and run the engine?
3- Adjust the thermal relay to the motor current rating by reading the motor nameplate?
4- Why does the engine stop?
5- Which indicator lights up?
6- How do I reset the thermal relay?
7- Give a conclusion?

Practical Task 4: Starting an asynchronous motor in two running directions

Pedagogical objectives :

- Identify the nameplate of a star-delta asynchronous motor.
- Know the structure of signaling devices.
- Insert auxiliary contact block.
- Know the purpose of mechanical and electrical locking devices.
- Starting a three-phase asynchronous motor in two directions of rotation
- Master the operating diagram.

1. Reminders

To change the direction of rotation of a three-phase induction motor, reverse two of the three phases of the supply circuit, as shown in figure

1.1 Determining the coupling Based on the information given on the motor nameplate and the mains supply, the user must couple the stator windings in the correct delta or star configuration.

If the lowest voltage on the motor nameplate corresponds to the voltage between phases of the network**,** we adopt **the Δ coupling.**

If the highest voltage on the motor nameplate corresponds to the voltage between mains phases, **Y-coupling is** adopted.

1.2 Winding coupling on the terminal board Terminal strips are used to ensure the selected coupling of the windings on the motor terminal board.

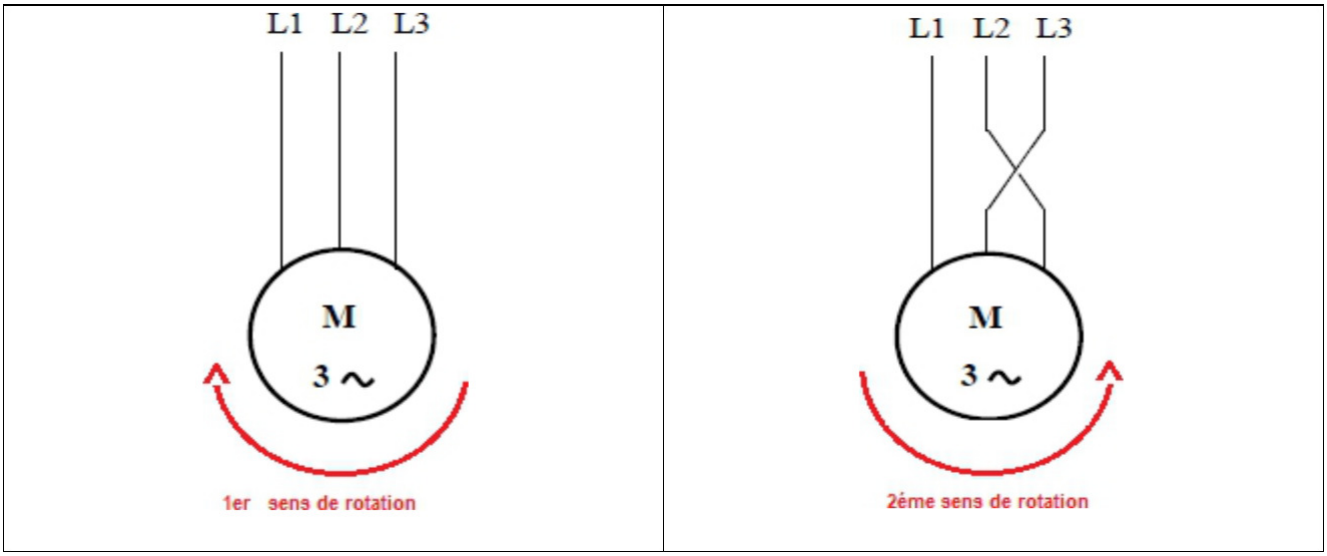


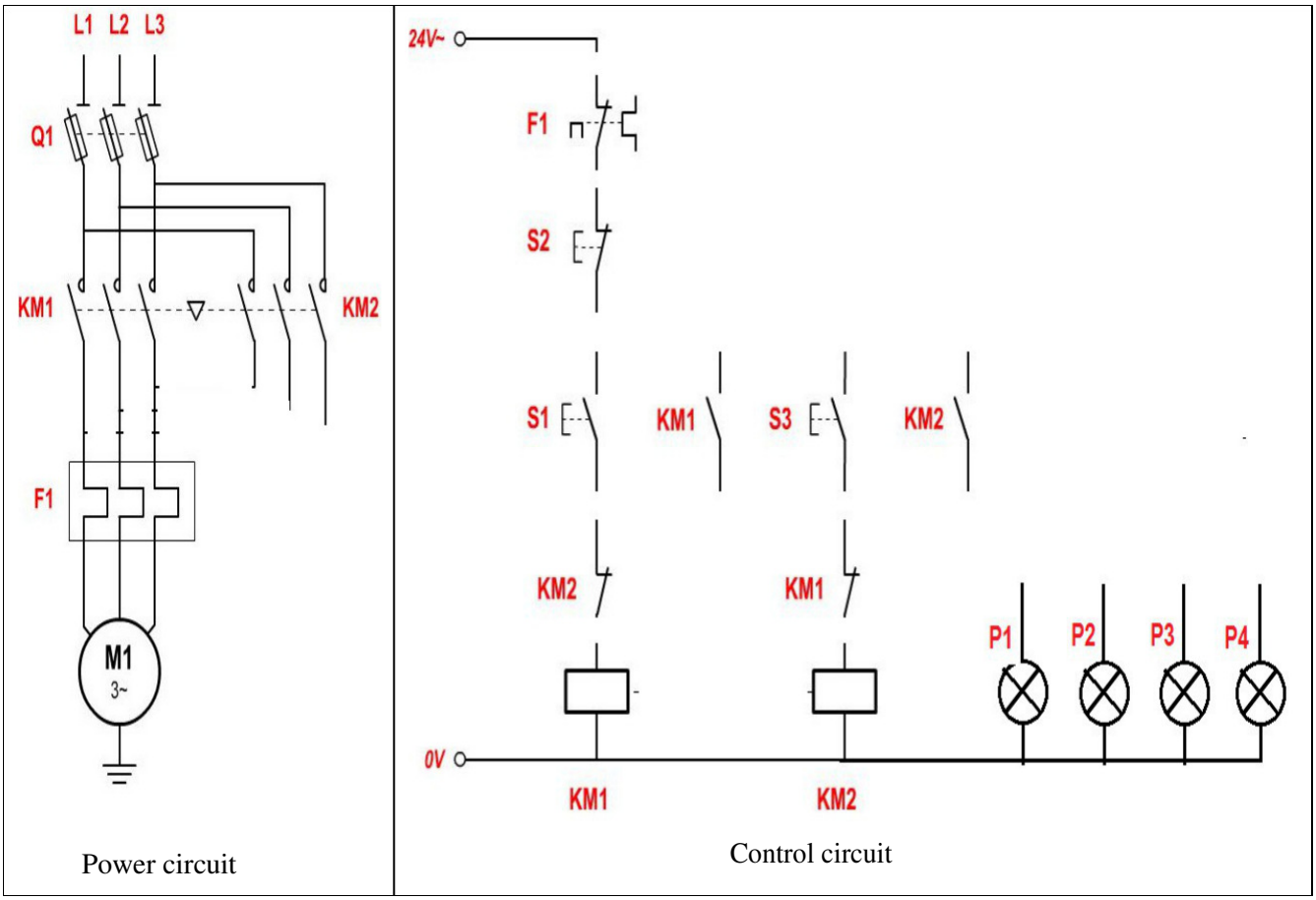
Figure 1: Asynchronous motor rotation reversal principle

2. Handling

2.1 Equipment and materials used (see Figure 1)

- FESTO experimental p a n e l
- 24V FESTO power supply
- Universal multimeter
- 2x Siemens 24V contactors
- Thermal relay
- 2xauxiliary contact block
- 0.7kW three-phase motor

Consider the following control and power diagram for a three-phase motor:



Power circuit

Control circuit

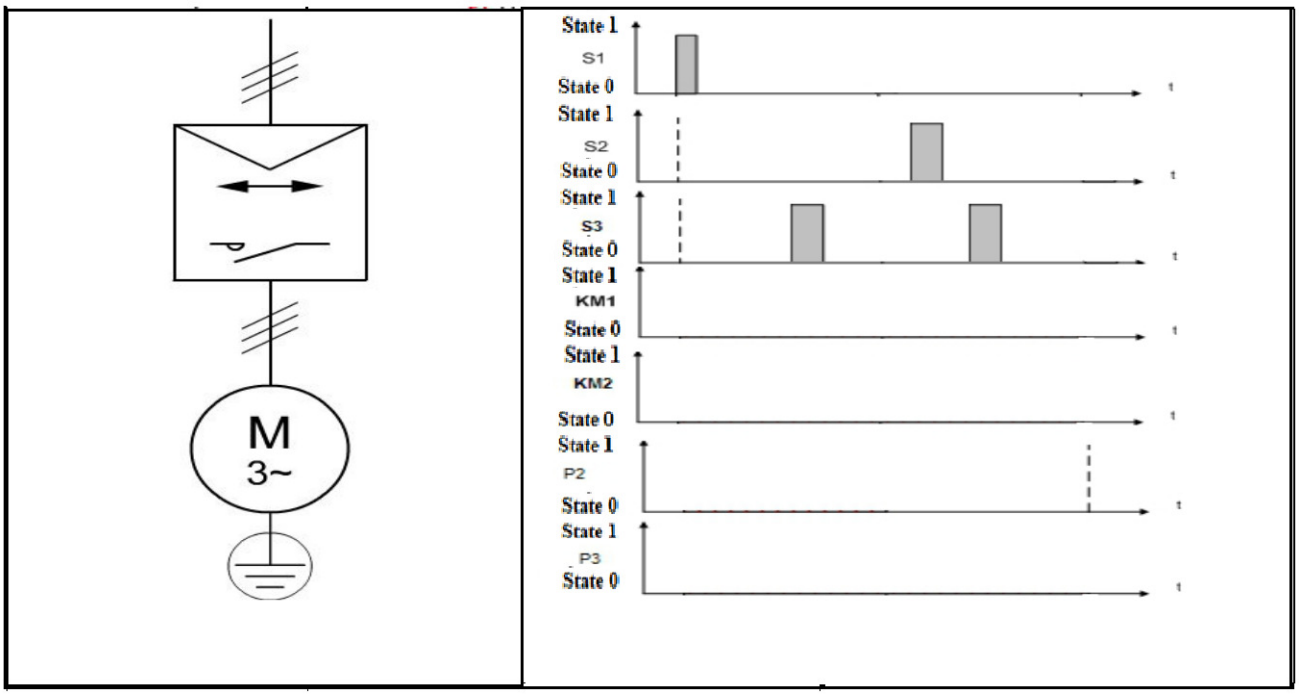
P1: Power-on indicator lamp.

P2: indicator lamp for right-hand drive.

P3: Indicator lamp for left-hand operation.

P4 : Indicates overload fault.

The two-way rotation block diagram for an asynchronous motor and the operating diagram are shown in the following figure:



Function diagram Operating diagram

Activity :

1- Complete the diagrams above and the chronogram corresponding t o motor operation?
2- Make the circuit and turn the motor left and right?
3- Give a conclusion?

Practical task 5: Star/delta starting of an induction motor

Learning objectives :

- Identify the nameplate of a star-delta asynchronous motor.
- Know the structure of timing and signalling devices.
- Insert auxiliary contact block.
- Know the purpose of mechanical and electrical locking devices.
- Starting a three-phase asynchronous motor in two directions of rotation
- Master the operating diagram.

1. Reminders

1.1 Starting current limiting principle

In contrast to direct starting, the starting of medium and high-power motors requires the use of starting current limiting procedures, while maintaining the mechanical performance of the motor/driven machine assembly.

There are two technical types of action:

Action on the stator, which consists in reducing the voltage across the stator windings: Star-delta coupling, Elimination of stator resistances, Use of an auto-transformer.

Action on the rotor: Increases rotor resistance on start-up: Elimination of rotor resistance, Use of multi-cage motors ...

In addition to reducing starting current, this starting method also increases starting torque. This type of starting is used for high-power motors.

1.2 Star-delta starting

The engine starts in two stages:

1st step: each stator winding is supplied with a reduced voltage U/√3 using Y coupling.

t1 is the time required for the motor speed to reach approximately 80% of its rated speed.

2nd step: each stator winding is supplied with its rated voltage, changing the delta coupling.

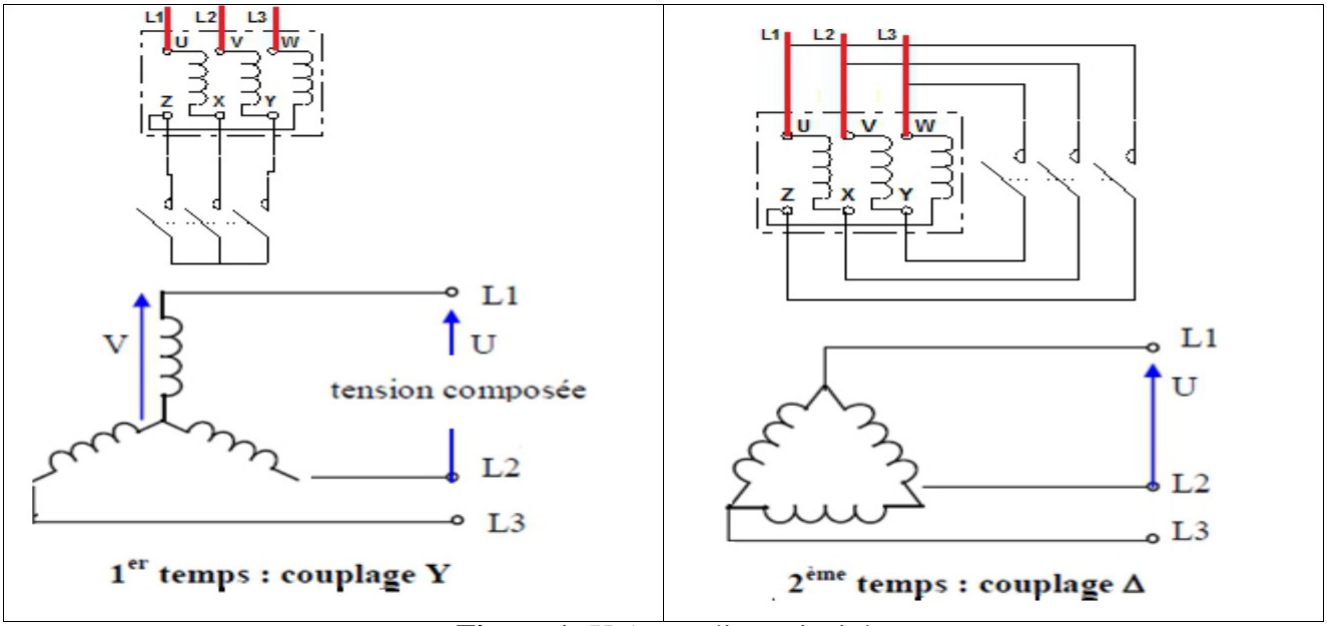


Figure 1: Y-Δ coupling principle

This type of starting is used for Δ-coupled motors during normal operation.

Example:

A 400V/690V motor on a 230V/400V network A

230V/400V motor on a 133V/230V network

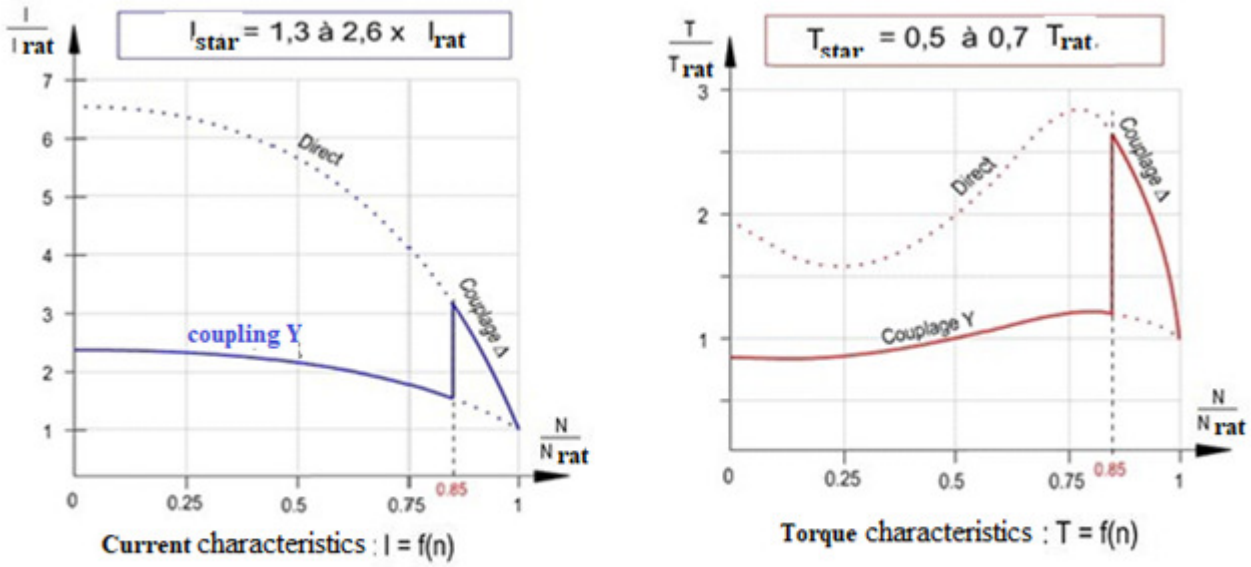


Figure 10: Torque-current characteristics as a function of speed

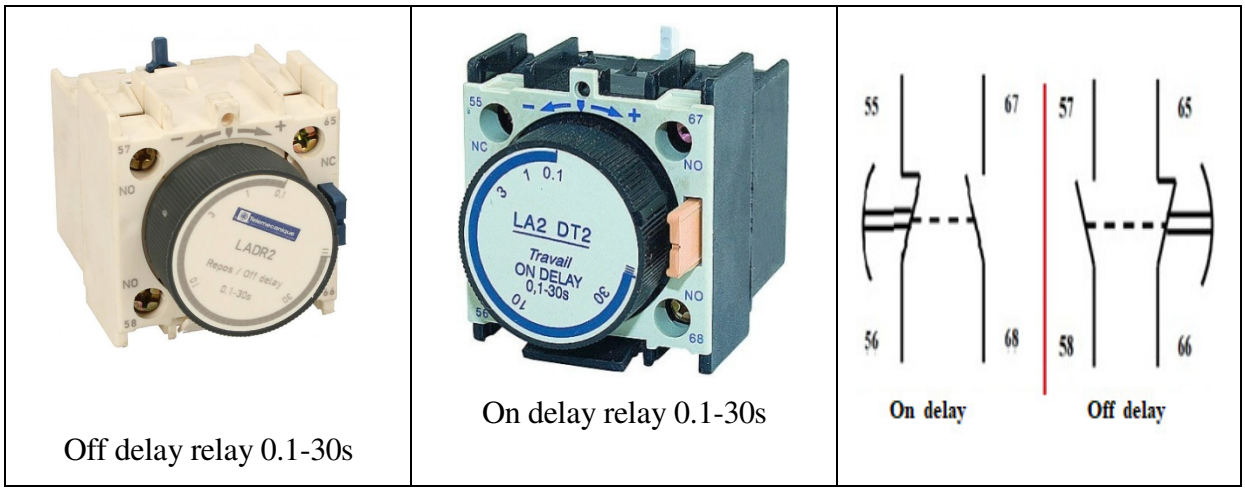
Torque and current at start-up are reduced b y around 3 times compared to direct starting.

Due to the significant reduction in starting torque, the motor cannot start under load.

1.3 Time delay

To achieve automated switching from Y to Δ coupling, we use a timed contact that makes or breaks a contact after certain preset times to enable our equipment to operate properly.

The timed contact enables a contact to be made or opened a certain time after the contactor which actuates it has closed (when working) or opened (when idle).



Off delay relay 0.1-30s

On delay relay 0.1-30s

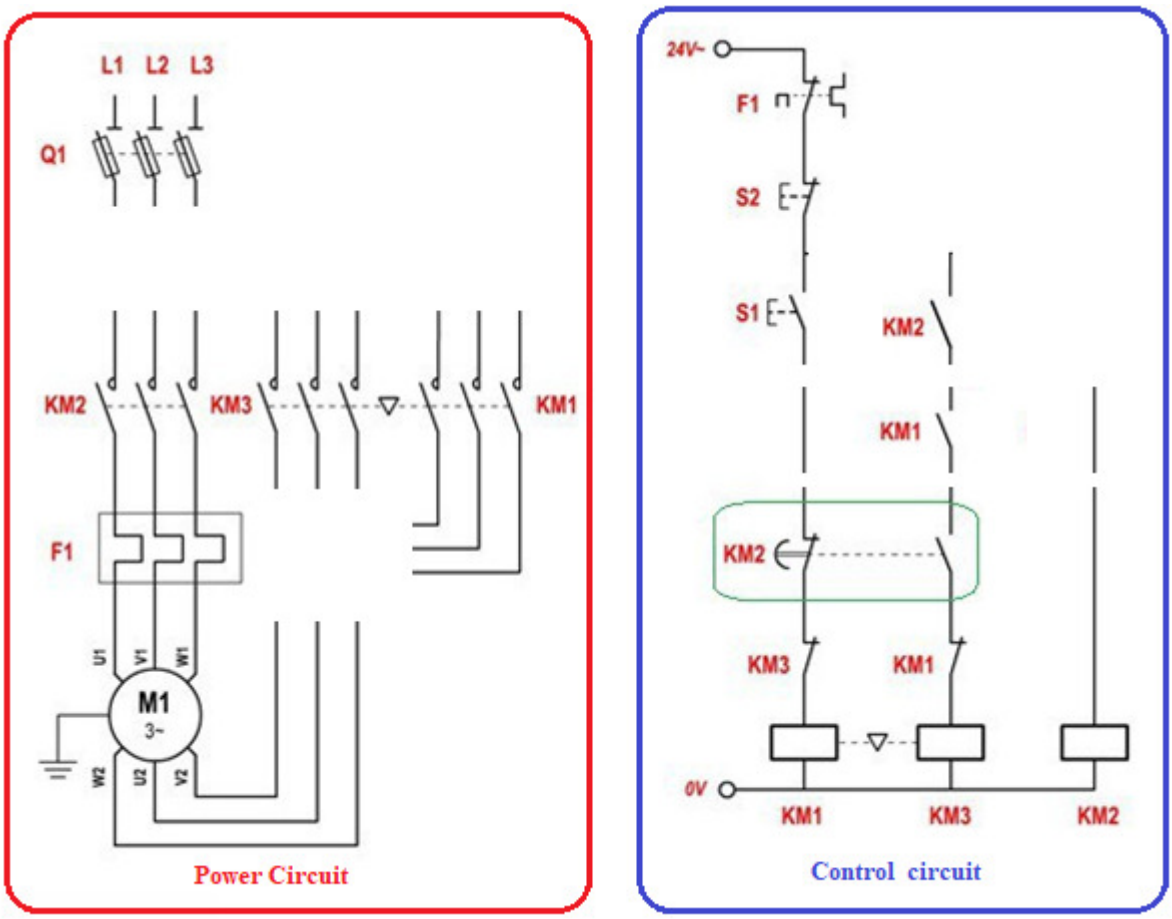
Figure 11 : Timer relay

2. Handling

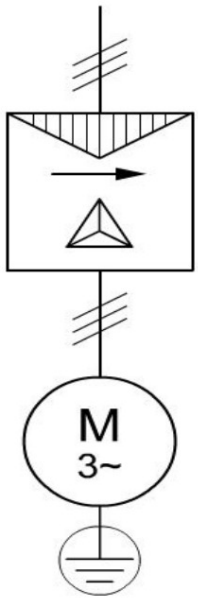
2.1 Equipment and materials used

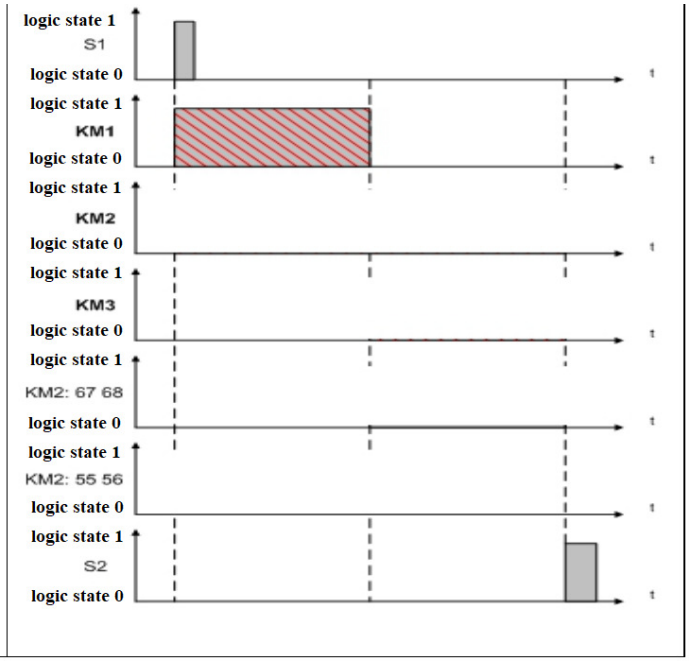
- FESTO experimental panel
- 24V FESTO power supply
- Universal multimeter
- 3x Siemens 24V contactors
- Thermal relay
- Timer relay 0.1-30s

Consider the following control and power diagram for a three-phase motor:



The block diagram of the Y-Δ start-up of an induction motor and the operating diagram are shown in the following figure:

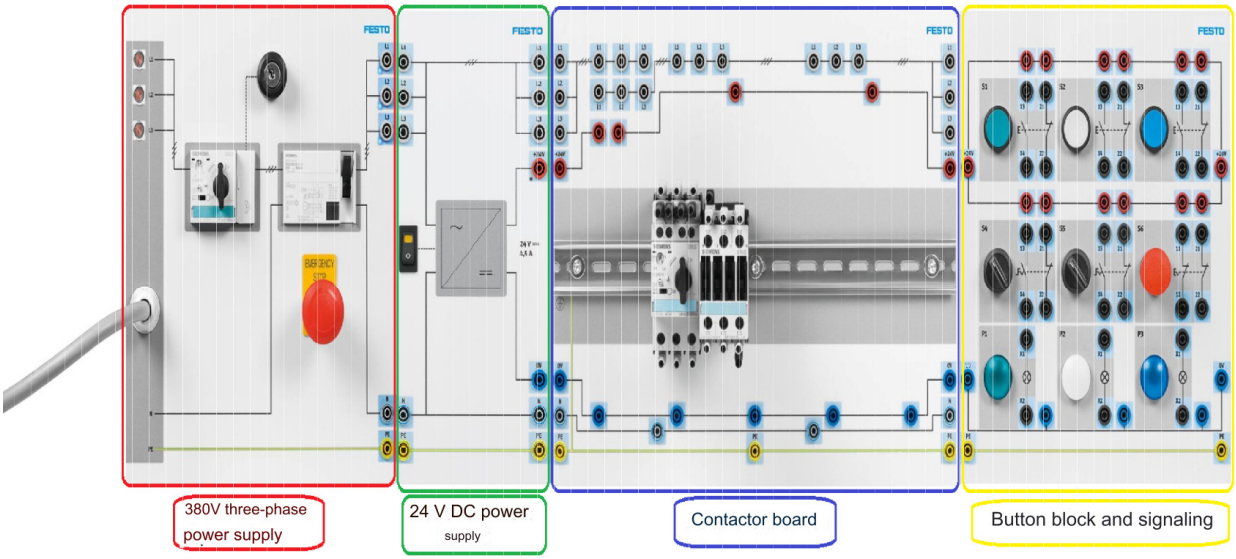




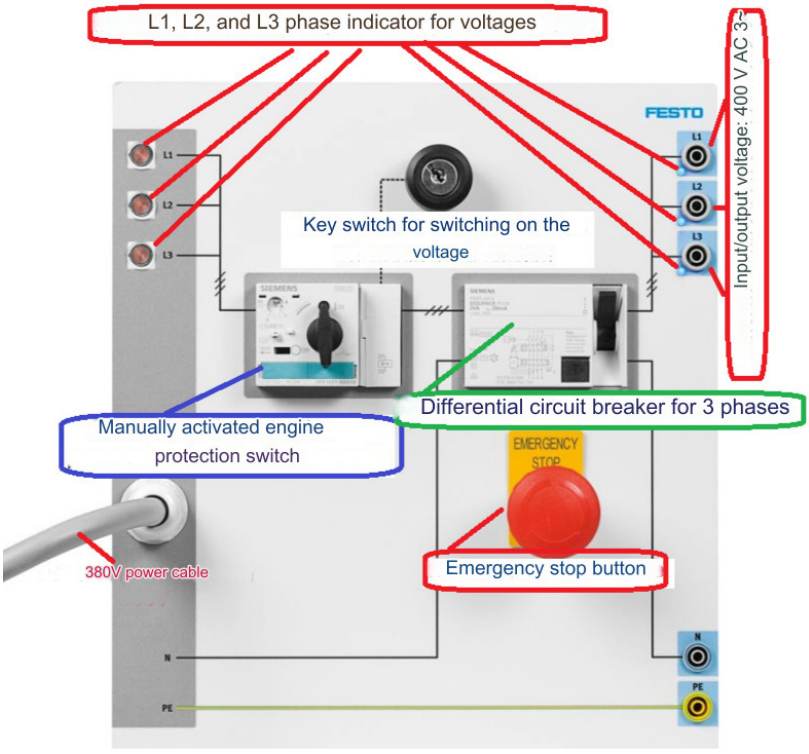
Activity :

1- Complete the diagram above and the corresponding chronogram?
2- Make the circuit and turn the motor left and right?
3- Give a conclusion?

Appendix 1: Experimental panel in use



Appendix 2: Three-phase power supply unit

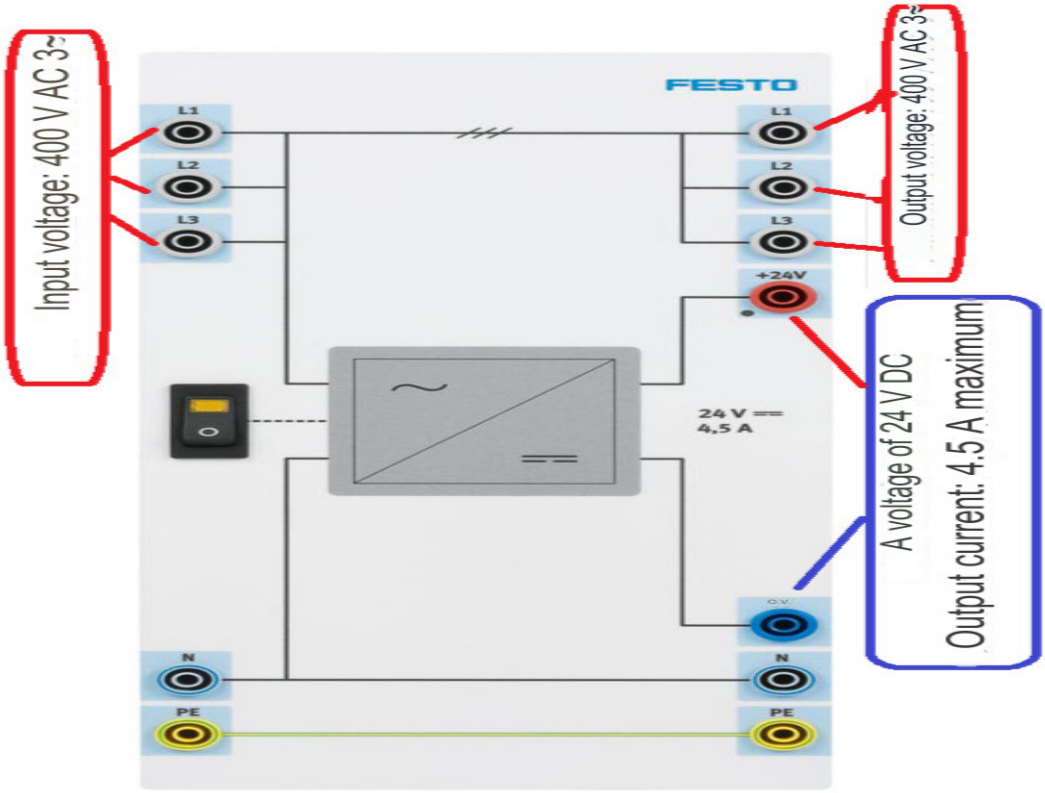


The three-phase power supply unit:

- A safe power supply:
  - Manually activated motor protection switch
  - 3-phase differential circuit breaker
  - Emergency stop button

- Input/output voltage: 400 V AC 3~
- Output current: 6 A maximum
- Phase indicators L1, L2, and L3 for voltages
- Key switch for voltage switch-on

Appendix 3: 24 V DC power supply unit



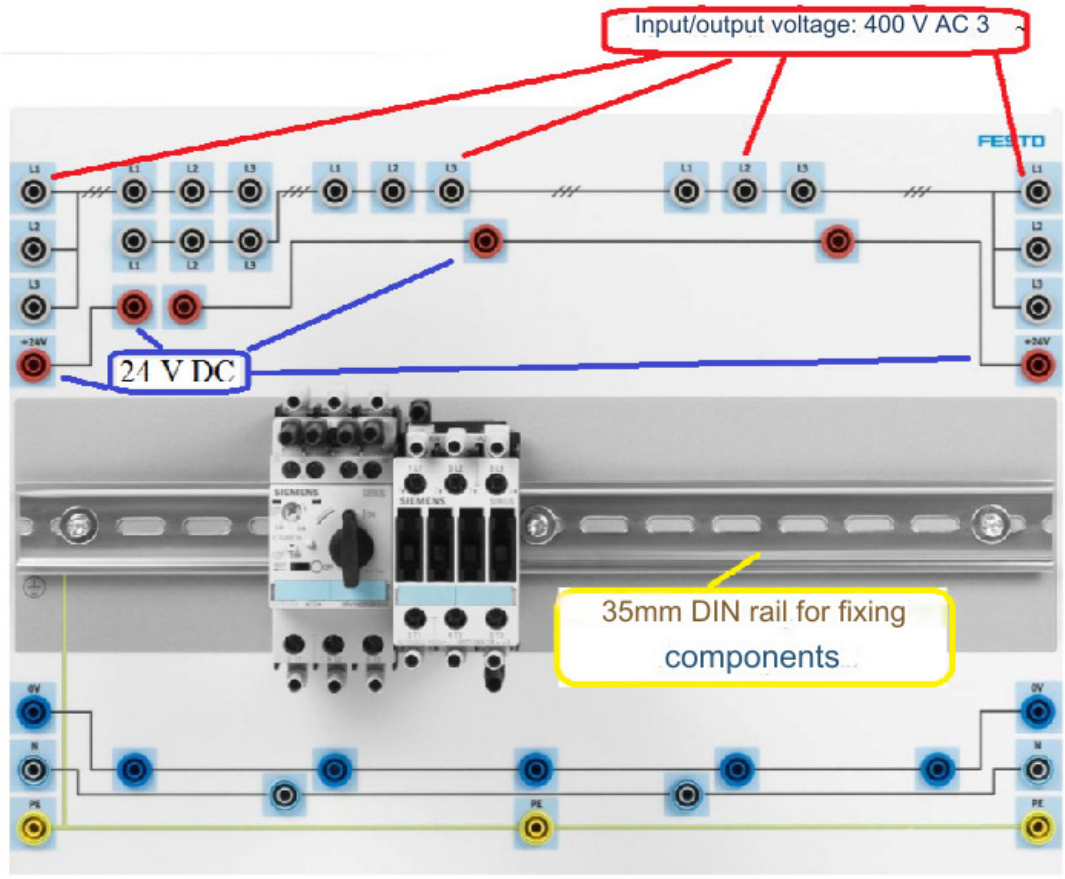
The 24 V DC power supply unit:

- **24 V DC voltage**

Technical specifications:

- **Input voltage: 400 V AC 3~**
- **Output voltage: 24 V DC**
- **Output current: 4.5 A maximum**

Appendix 4: Contactor board



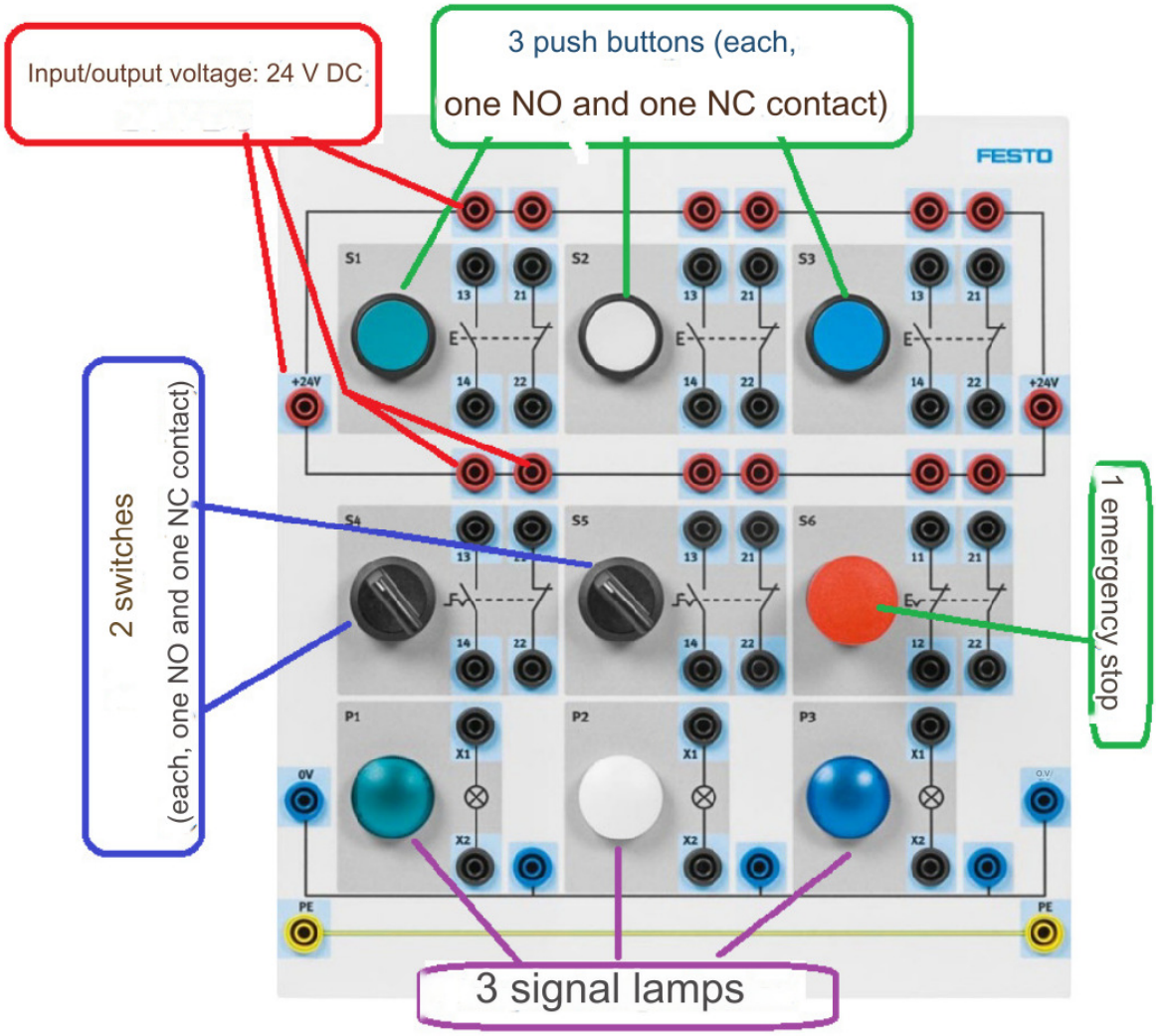
Contactor board:

- Mounting the various components

Technical specifications:

- **Input/output voltage: 400 V AC 3~; 24 V DC**
- **35mm DIN rail for component mounting**
- **Voltage distribution 400 V AC 3~ and 24 V DC**

Appendix 5: Button and signalling units :



Buttoning and signalling block :

This block contains:

- 3 pushbuttons (each with NO and NC contacts)

- 2 switches (each with NO and NC contacts)

- 1 emergency stop

- 3 signal lamps

Technical specifications:

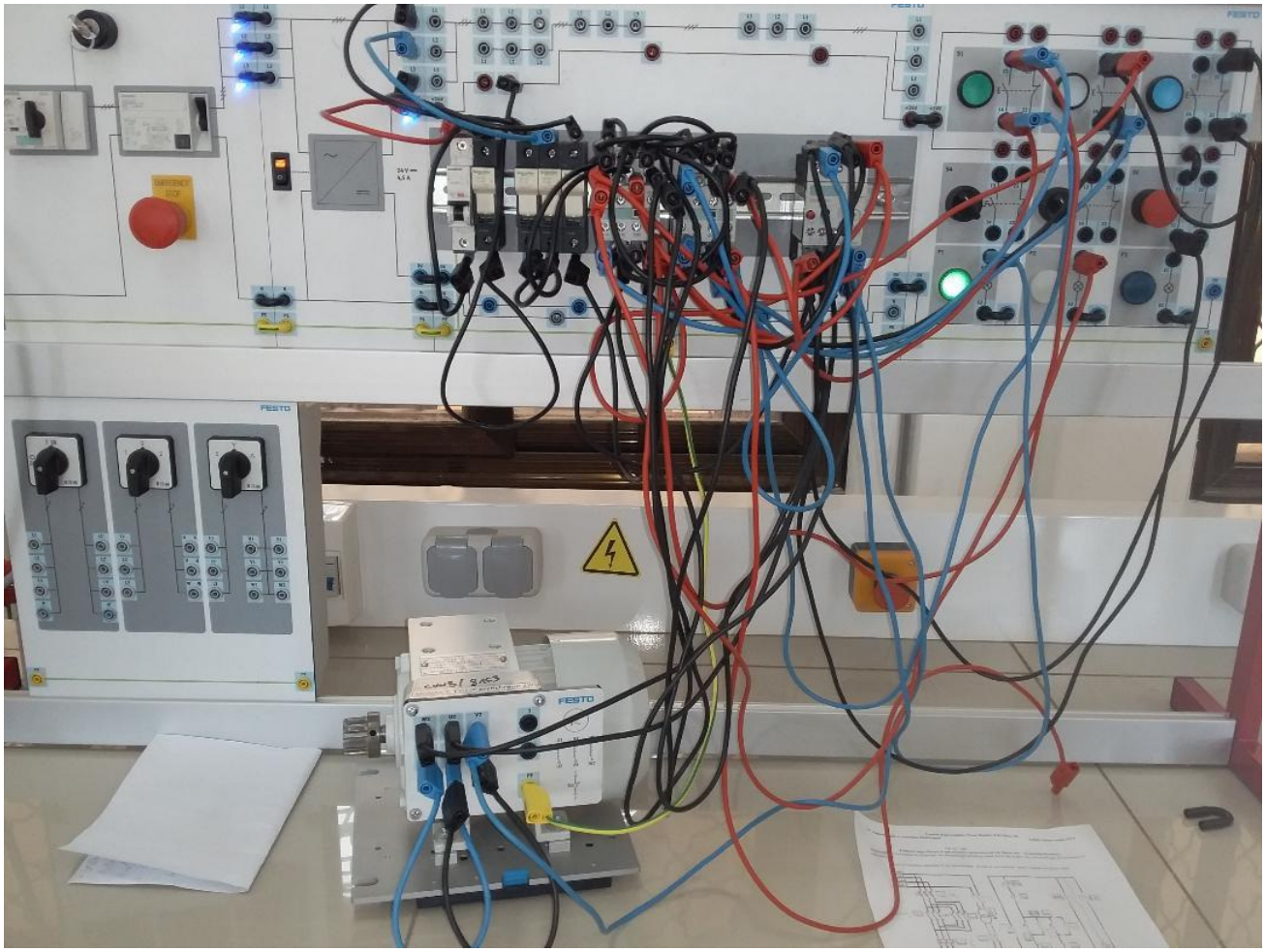
- Input/output voltage: 24 V DC

- Maximum acceptable current: 16 A

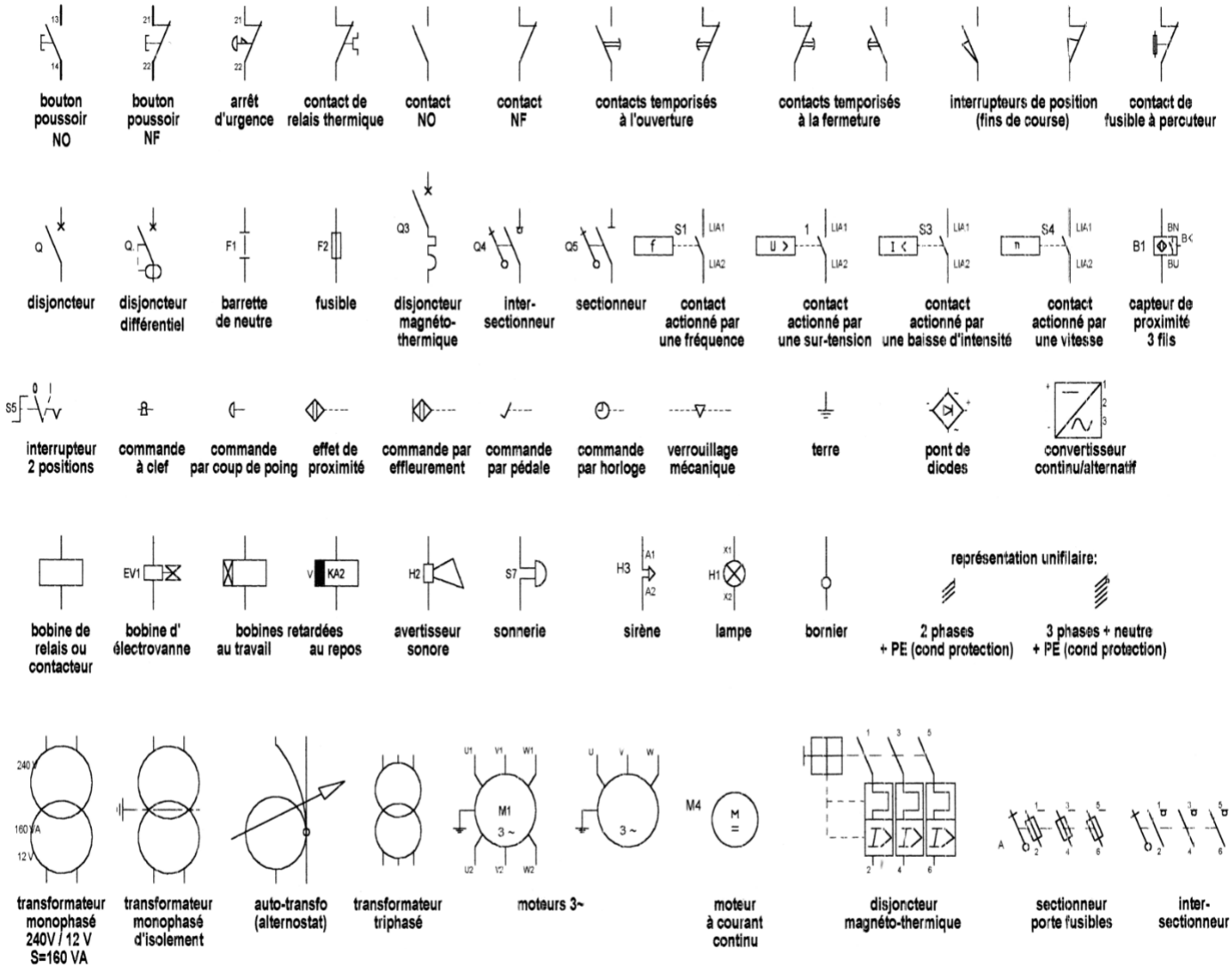
- Integrated 24 V DC distribution

Appendix 6: Photo of the operation Practical Task 4

(Bidirectional starting of an induction motor wiring)



Appendix 7 : Standardized Electrical Symbols in French



APPAREILLAGE D'INSTALLATION

Fonctions de l'appareillage

- Fonction disjoncteur
- Fonction sectionneur
- Fonction interrupteur-sectionneur
- Fonction déclenchement automatique
- Contact à fermeture (contact de travail)
- Contact à ouverture (contact de repos)
- Bobines de commande
- Elément de protection thermique
- Elément de protection magnétique

Appareillage à fonction simple

- Sectionneur
- Interrupteur (commande)
- Fusible (protection contre les surintensités)
- Contacteur (commande)
- Rupteur (commande)
- Bouton-poussoir à fermeture et retour automatique
- Tirette à ouverture et retour automatique

Appareillage à fonctions multiples

- Fusible interrupteur
- Discontacteur
- Fusible sectionneur
- Interrupteur-sectionneur
- Fusible interrupteur-sectionneur
- Disjoncteur
- Fusible à percuteur
- Disjoncteur tripolaire à relais magnétothermiques
- Disjoncteur différentiel
- Contacteur tripolaire avec contact auxiliaire à deux directions

Appareillage de protection contre les surtensions

- Eclateur
- Eclateur double intervalle
- Limiteur de surtension
- Parafoudre

Appareillage de connexion

- Fiche de prise de courant
- Socle de prise de courant
- Fiche et prise associées

Autres formes

- Fiche mâle
- Prise femelle
- Fiche et prise associées

APPAREILS DE PRODUCTION ET TRANSFORMATION

- Générateur
- Batterie de piles ou accus
- Transformateur
- Transformateur triphasé triangle/étoile
- Transformateur de courant
- Transformateur tore
- Autotransformateur

APPAREILS DE MESURE

Indicateurs

- V — Voltmètre
- A — Ampèremètre
- W — Wattmètre
- var — Varmètre
- H2 — Fréquencemètre

Enregistreurs

- Wh — Compteur d'énergie active (wattheuremètre)
- varh — Compteur d'énergie active (varheuremètre)

CANALISATIONS

- Conducteur de phase
- Neutre
- De protection (terre)
- 5 conducteurs (3 P + N + T)
- Connexion borne
- Connexion barrette
- Croisement de 2 conducteurs avec connexion
- Sans connexion
- Dérivation
- Boîte de jonction non enterrée

APPAREILS D'UTILISATION

- Lampe d'éclairage (symbole général)
- Tube à fluorescence
- M — Moteur
- Sonnerie
- Résistance
- Condensateur
- Z — Impédance
- Eclairage de sécurité sur circuit spécial
- Bloc autonome d'éclairage de sécurité