PL 11 & 12 – Electric circuits to operate induction motors

Objectives: Analysis of electric circuits (control and power circuits). Identification of the main components, their symbols and main operational characteristics.
Resolution of proposed case studies.

Support material
Hardware Systems and respective electrical circuits documents available:
1) *System-I,* 3 phase induction gearmotor, circuit for inverting running direction and timed operation
2) *System-II,* 3 phase Induction motor, circuit for startup using star-delta commutation
3) *System-III,* 3 phase Induction motor, circuit for inverting running direction
4) *System-IV, Didactic Setup by Sprecher, three-phase induction motor (inversion of running direction)*
5) *System-V, Two speed induction motor, control circuit*

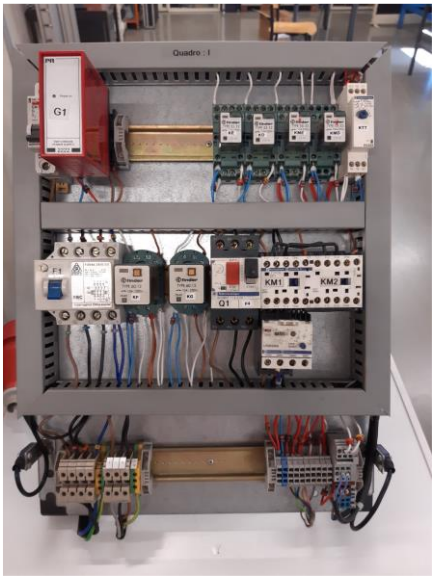
2026 2026 Lab_ Control Circuits.pdf
2026 SE TP Low_Voltage_Swithgear.pdf
2026 SE TP Starting methods for induction motors.pdf
2026 SE TP Control circuits for electrical motors.pdf
Links: Omron_ https://www.ia.omron.com/
Schneider https://www.se.com/ww/en/work/products/industrial-automation-control/
Schneider catalogue
Siemens https://sieportal.siemens.com/pt-pt/home
ABB https://www.lowvoltage-tools.abb.com/soc/Motor

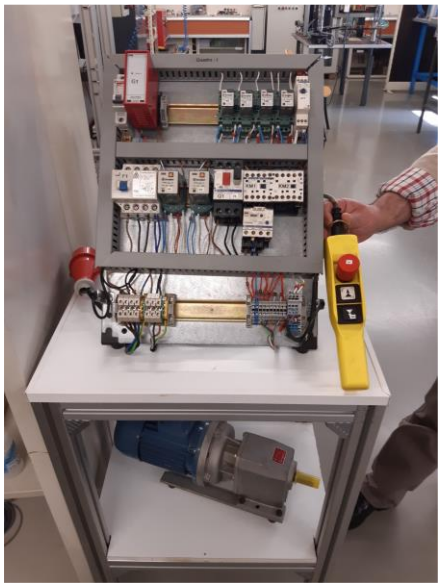
A. Analysis of electric circuits and Identification of the main components

Consider the following five hardware systems available in the lab and the respective electrical circuits (2026 Lab_ Control Circuits.pdf)

Exercise 1 System I – Three-phase gearmotor

Command of a 3-phase induction motor for inverting the running direction and for limiting the motor operation time.



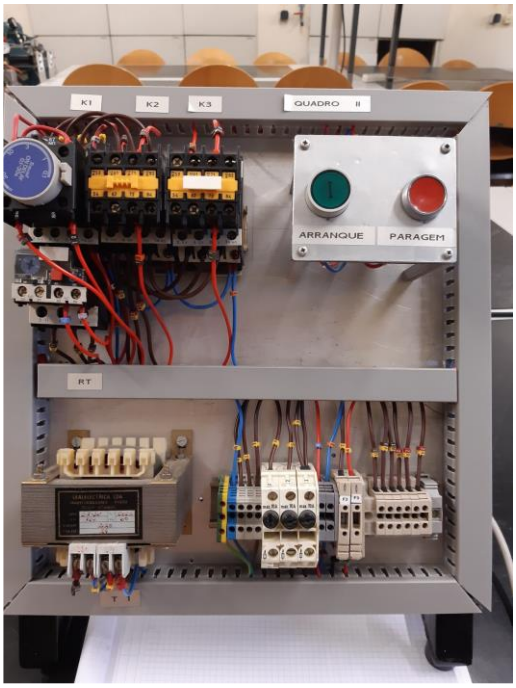


Based on the analysis of the electric components present in the electric circuits of the system, fill the following Table

Id code	Designation/Main function	Manuf. code	Symbol and main characteristics	Power/ Control
F1				
F3				
Q1				
G1				
KM1, KM2				
F2				
M1				
BD, BE				
KE, KD,				
KF, KG				
KTT				
S1				
SE, SD				

Exercise 2: System-II, electric circuit for star-delta commutation during startup

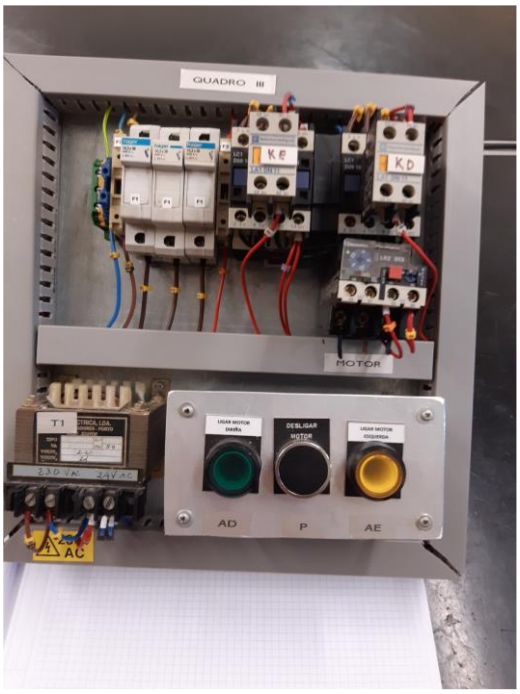
Based on the analysis of the electric components present in the electric circuits of the system, fill the following Table



Id code	Designation/Main function	Manuf. code	Symbol and main characteristics	Power/ Control
F1 (3x)				
F1 (3x)				
F2				
F3				
K1				
K2, K3				
F4				
M, P				
T1				

Exercise 3: System-III, inverting running direction of 3-phase induction motor

Based on the analysis of the electric components present in the electric circuits of the system, fill the following Table

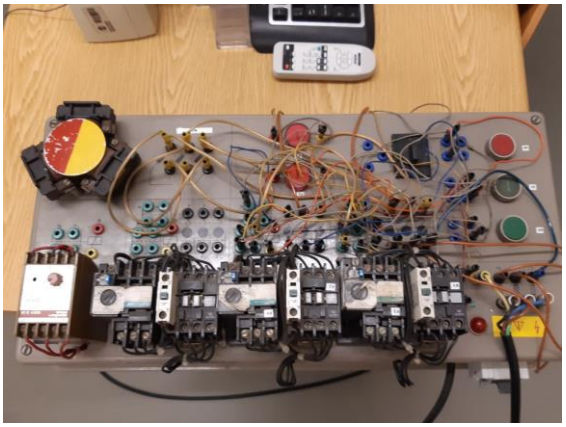


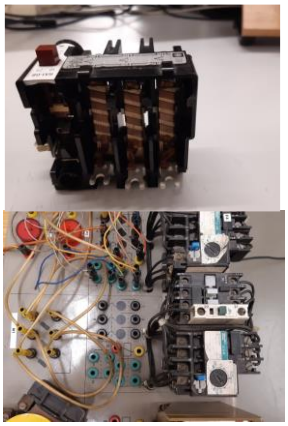
Id code	Designation/Main function	Manuf. code	Symbol and main characteristics	Power/ Control
F1 (3x)				
F1 (3x)				
F2				
F3				
KE, KD				
RT				
AD, AE				
T1				

Exercise 4: System-IV, didactic setup by Sprecher

a) Identify if the motor is configured with a star or delta connection.

b) Based on the analysis of the electric components present in the electric circuits of the system, fill the following Table

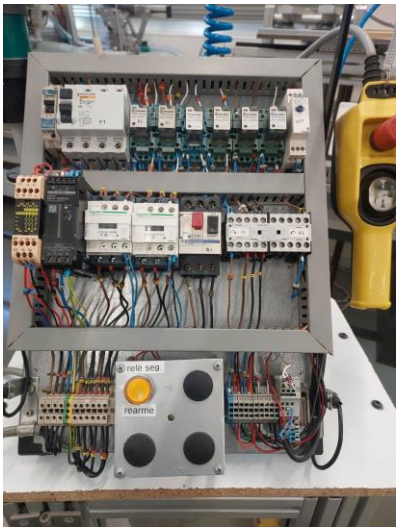


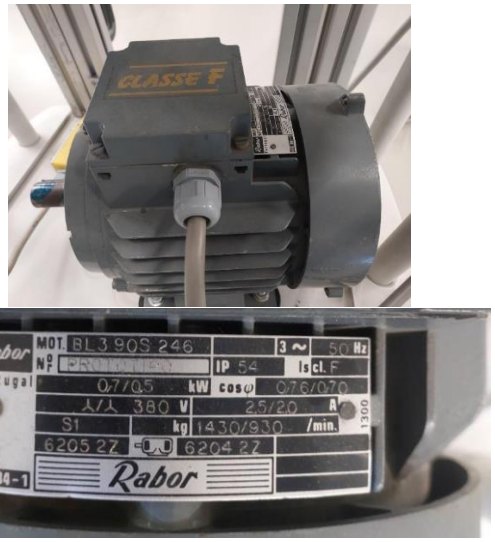


Id code	Designation/Main function	Manuf. code	Symbol and main characteristics	Power/ Control
F1				
F2				
K1, K2				
F3, F4				
S0, SI, SII				
P1, P2 (1, 2)				

Exercise 5: System-V, Two speed induction motor

Control of a two-speed induction motor (6 wires motor)





Based on the analysis of the electric components present in the electric circuits of the system, fill the following Table

Id code	Designation/Main function	Manuf. code	Symbol and main characteristics	Power/ Control
F1				
T5				
Q1				
F3				
K1, K2,				
K300, K400				
S1			-	-
S34				
RS				
S30				
S31				

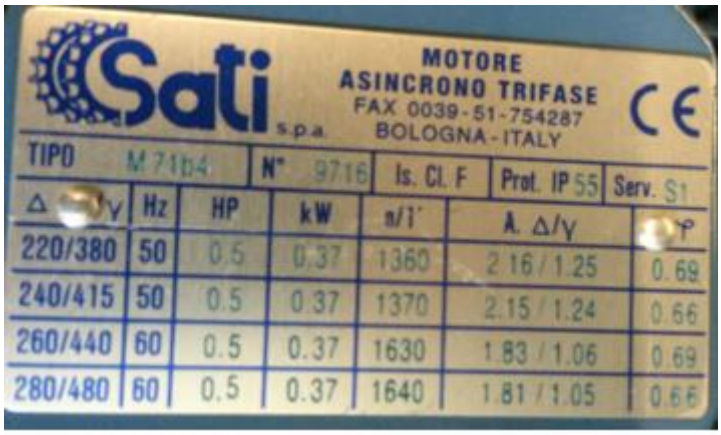
S13				
R1, R2				
R3, R4, R5				
B10, B11				
P9, P10, P11				

Part B – Exercises

Exercise 1: Direct-On-Line (DOL) Starter with Thermal Overload Sizing

Objective: Introduction to basic power and control topology, component identification, and introductory switchgear sizing.

- **Task Part A (Analysis):** Draw a standard DOL starter for a 3-phase induction motor. Consider the use of a circuit breaker, contactor, thermal overload relay, and motor.
- **Task Part B (Sizing):** Consider the motor with the following motor plate



  1. Obtain the motor's full-load rated current and the motor efficiency
  2. Size and select the appropriate setting range for the thermal overload relay
  3. Choose a suitable miniature circuit breaker (MCB) and contactor
- **Deliverable:** Completed schematic, a structured component list (Designation, Function, standard IEC Symbol), and sizing calculations.

Exercise 2: Forward-Reverse Control Circuit with Electrical Interlocking

Objective: Implementation of logical control constraints, safety interlocking mechanisms, and cable sizing.

- **Task Part A (Control Logic Design):** Design and draw a control circuit that allows a motor to run in both forward and reverse directions using two distinct push buttons (B1 and B01) and a stop button (B0).
    - *Constraint:* The circuit must include electrical interlocking using auxiliary contactor contacts to prevent both forward and reverse contactors (K1 and K2) from closing simultaneously (which would cause a catastrophic phase-to-phase short circuit).
- **Task Part B (Sizing):** Consider the induction motor has a power rate of 3 kW, 400 V, synchronous speed 3000 rpm, IE3. Consider the control circuit is powered by a 230 V AC power supply.

  Consider the existence of a relay for detecting the loss of a phase.

  Based on the identified motor current, select the minimum copper cable cross-sectional area considering a fixed voltage drop limit (e.g., maximum 3%), considering that the power cables are 10 meters long.

- **Deliverable:** Completed schematic, a structured component list (Designation, Function, standard IEC Symbol), and sizing calculations.

Exercise 3: Automatic Star-Delta (Y-Delta) Starter with Time Delay

Objective: Address high inrush current mitigation, timing-based logical control, and specialized component selection.

- **Task Part A (Component Mapping):** Provide a complete schematic of a standard automatic star-delta starter. Identify and label the distinct roles of the three contactors (Main K1, Delta K2, Star K3) and the electronic time-delay relay (RT).
- **Task Part B (Sizing & Selection):** considering using an induction motor suitable for star /delta start with rated power 7.5 kW, 400V. For control circuit consider using a molded case circuit breaker and a thermal overload relay. Select the exact manufacturing codes for the required components

- **Deliverable:** Completed schematic, a structured component list (Designation, Function, standard IEC Symbol).