# Electrical layout and wiring schematics for a small industrial control panel

A complete electrical layout and wiring schematic for an industrial control panel requires detailed calculations, CAD drawings, and a design report. The following provides an overview based on the specified IEC standards, including core components, preliminary calculations for cable sizing and protection, and a summary of the design report's contents.

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**Design standard and report summary**

- **Selected standard:** IEC (International Electrotechnical Commission) standards, which are widely accepted internationally, will be followed for this design. The assembly will comply with IEC 61439-2 /NFPA for low-voltage switchgear and control gear assemblies.
- **Design report contents:** The accompanying design report will include key assumptions and calculations.

    1. **Assumptions:** Nominal voltage (V) is 400 V, 3-phase, 50 Hz. All motors are of efficiency class IE3 and controlled via Direct On-Line (DOL) starters. Cable lengths are assumed to be 20 meters.
    2. **Safety factors:** A diversity factor will be applied to the total power calculation. Cable sizing will include derating factors for ambient temperature, grouping, and installation method. A safety factor of 1.25(Design current) is included in the motor current calculations.
    3. **Load balancing:** Single-phase loads (Machine C) will be balanced as evenly as possible across the three phases to minimize neutral current and voltage imbalances.

    **Cable Length & Voltage Drop Assumptions**

| Parameter | Value / Assumption |
|---|---|
| Cable length to machines | 15 m each |
| Voltage drop limit | ≤ 3 % (11.5 V for 400 V system) |
| Correction factor for temperature | 0.9 |
| Derating for grouping | 0.8 |
| Safety margin | 20 % extra capacity |

**Preliminary calculations (IEC-compliant)**

1. **Machine A (5 kW, 400V, 3-phase motor)**

1. **Full load current ($I_A$)**

$$I_A = \frac{P}{\sqrt{3}.V.cos\,\phi.\eta} = \frac{5000}{\sqrt{3}.400.0.85.0.9} = 9.47\ A$$

**. Design current ($I_B$):** $I_B = 9.46A \times 1.25 = 11.83$

(Assuming power factor $\cos\phi$=0.85, efficiency $\eta$=0.9).

2. **Protection device (MPCB Q2):** A 3-pole MCB with a C-curve rating of 16 A would be a suitable choice for this motor, as the motor starting current is relatively small for a DOL starter.

3. **Cable sizing ($Cable\ A$):** A 5-core (L1, L2, L3, N, PE) copper cable with a cross-sectional area of 2.5 mm² is appropriate for this current, after applying relevant derating factors for the assumed installation method.

2. **Machine B (2 kW, 400V, 3-phase motor)**

1. **Full load current ($I_B$):** $= \frac{P}{\sqrt{3}.V.cos\,\phi.\eta} = \frac{2000}{\sqrt{3}.400.0.85.0.95} = 3.8\ A$

**. Design current ($I_B$):** $I_B = 3.8 \times 1.25 = 4.8A$

(Assuming power factor $\cos\phi$=0.85, efficiency $\eta$=0.85).

2. **Protection device (MPCB Q3):** A 3-pole MCB with a C-curve rating of 10 A is suitable. (In **case if future motor addition**).

3. **Cable sizing ($Cable\ B$):** A 5-core (L1, L2, L3, N, PE) copper cable with a cross-sectional area of 1.5 mm² is appropriate for this current.

3. **Machine C (Lighting and sockets, 230V, single-phase)**

1. **Full load current ($I_C$):** This depends on the total connected load, which is assumed to be 3 kW**. Ic** $= \frac{P}{.V.cos\,\phi} = \frac{2000}{230.\ 1} = 8.7A$ ($\cos\phi$=1 for R-Load)

**Design current ($I_C$):** $I_B = 8.7 \times 1.25 = 10.88A$

2. **Protection device (MCB Q4):** A 1-pole MCB with a C-curve rating of 16 A would be a suitable choice for this Load current.

2. **Protection device (RCD))**: An RCD/**RCBO with a sensitivity of 30mA** must be used for human protection.

**4. Cable sizing (*Cable* C):** A 3-core (L, N, PE) copper cable with a cross-sectional area of 2.5 mm² is appropriate for this current, after applying relevant derating factors for the assumed installation method.

| Load | Power | Voltage | Phases | Power Factor | Current (A) | Recommended Breaker | Cable Size (Cu) |
|---|---|---|---|---|---|---|---|
| Machine A | 5 kW | 400 V | 3-φ | 0.85 | I=5000/1.732×400×0.85x 0.9=9.47A | 16 A TP MCB | 2.5 mm² |
| Machine B | 2 kW | 400 V | 3-φ | 0.85 | I=2000/1.732×400×0.85x 0.95=3.8A | 10 A TP MCB | 1.5 mm² |
| Machine C | 3 kW (equiv.) | 230 V | 1-φ | 0.95 | I=2000/230×1=8.7A | 16 A SP MCB + RCD | 2.5 mm² |

**4. Main breaker and distribution board**

a. **Total assumed load current (I total)** : Summing the individual currents ($I_A$+$I_B$+$I_C$) with a diversity factor of 0.8 yields an estimated total current of approximately 27.5 A.

b. **Main breaker (MCCB Q1)**: A 4-pole MCB with a C-curve rating of 32 A would be a suitable main incomer for the control panel.

C. **Main cable sizing (Main Cable):** A 4-core (L1, L2, L3, N) copper cable with a cross-sectional area of 10mm² is selected to feed the main breaker, based on the total load current and derating factors.

**Panel Components**

**Main Incomer:** 32A, 4-pole MCCB (rated for the total panel load).

**Machine A:** 16A, 3-pole MPCB with integrated thermal overload.

**Machine B:** 10A, 3-pole MPCB with integrated thermal overload.

**Machine C:** 16A, 1-pole MCB with a dedicated 30mA RCD.

**Internal Distribution**: Copper busbars for power distribution.

**Wiring**: PVC insulated copper wires with specified cable sizes.

**Panel Enclosure: IP54**-rated metal enclosure to protect against dust and splashing water.

## 5. Wiring schematics and diagram annotations (In AUTOCAD 2021)

**Detailed Wiring Diagram**: The detailed diagram shows all connections, components, and cable numbers for panel assembly.

Component Legend:

Q1 : Main 32A MCCB (4-pole)

Q2 : 16A MPCB (3-pole) for Machine A

Q3 : 10A MPCB (3-pole) for Machine B

Q4 : 16A MCB (1-pole) for Machine C

K1 : Contactor for Machine A

K2 : Contactor for Machine B

F1 : Thermal overload relay for Machine A

F2 : Thermal overload relay for Machine B

S1 : Start/Stop buttons for Machine A

S2 : Start/Stop buttons for Machine B

RCD : 30mA Residual Current Device for Machine C

**CAD wiring diagram (illustrative schematic)**
The wiring diagram should include the following sections and adhere to IEC standards for labeling:

- **Incoming power:** A 400V, 3-phase, 50 Hz supply with a 4-pole main isolation switch.
- **Protection devices:** A main 4-pole MCB, followed by individual MCBs for each machine. An RCD or RCBO is included for Machine C.
- **Power and control circuitry:**
    - **Machine A & B:** These will use Direct On-Line (DOL) starters, which consist of a contactor (K1, K2) and a thermal overload relay (F1, F2) for motor protection.
    - **Machine C:** The lighting and sockets circuit is routed through the RCD and its own MCB.
- **Labels and legends:**

    - **Reference designations (IEC 81346):** Components will be labelled using standard prefixes (e.g., Q for breakers, K for contactors, F for overload relays).
    - **Wire numbering:** Wires will be numbered logically according to the circuit they belong to.
    - **Component legend:** A table defining all components used in the diagram.
- **Distribution board layout:** The physical arrangement of components within the panel, showing the control switches, sockets, MCCB& MPCBs, RCDs

**Safety features**

- **Short-circuit and overload protection:** Provided by the MCBs and thermal overload relays.
- **Grounding:** A robust earthing system will be installed, and all metallic parts of the panel will be grounded.
- **Arc flash protection:** The enclosure will have a sufficient IP rating for protection against dust and water ingress and potential arc flash.
- **Lockout/Tagout (LOTO):** The main isolator will be capable of being locked in the 'off' position during maintenance.
- **Clearance:** Sufficient space between components will be maintained for heat dissipation and maintenance.