Building HVAC

Controls Training System

Building System Technology

User Guide

Festo Didactic
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Document Preliminaries

About this document

The operator should be familiar with the content of this document before installing and operating the equipment.

The Safety Symbols table at the beginning of this document lists safety symbols that may be present in this document or on the equipment.

This document is freely available for download from the Festo website.

Upon request, printed copies of this document are freely available. Contact your Festo Didactic sales representative.

Core documentation

The following courses provide the main instructional content for the Building HVAC Controls Training System, alongside this user guide. They describe theory and hands-on procedures students carry out using the system.

- Building HVAC – Direct Digital Control (BACnet)
- Building HVAC – Direct Digital Control (CGM Controllers)

These courses are available as printed workbooks, PDFs, campus licenses, or web courses on the Festo LX Portal.

Important. In this document, "the equipment" or "the learning system" refers specifically to the Building HVAC Controls Learning System.

Safety Symbols and Procedures

The following table lists the safety and common symbols that may be used in this document and on the equipment. Before performing procedures with the equipment, you should read all sections regarding safety in the User Guide accompanying the equipment. Additional safety procedures are given before any task requiring specific safety precautions.

Symbol	Description
⚠ DANGER	**DANGER** indicates a hazard with a high level of risk, which, if not avoided, will result in death or serious injury.
⚠ WARNING	**WARNING** indicates a hazard with a medium level of risk, which, if not avoided, could result in death or serious injury.
⚠ CAUTION	**CAUTION** indicates a hazard with a low level of risk, which, if not avoided, could result in minor or moderate injury.

Symbol	Description
NOTICE	**NOTICE** indicates a hazard with a potentially hazardous situation, which, if not avoided, may result in property damage.
	Caution, risk of danger. Consult the relevant user documentation.
	Caution, risk of electric shock.
	Caution, lifting hazard.
	Caution, hot surface.
	Caution, risk of fire.
	Caution, risk of explosion.
	Caution, belt drive entanglement hazard.
	Caution, chain drive entanglement hazard.
	Caution, gear entanglement hazard.

Symbol	Description
	Caution, hand crushing hazard.
	Static sensitive contents. Observe precautions for handling electrostatic discharge sensitive devices.
	Notice, non-ionizing radiation.
	Consult the relevant user documentation.
	Radio Equipment Directive (RED) geographical restrictions – consult the relevant user documentation.
	Direct current.
	Alternating current.
	Both direct and alternating current.
	Three-phase alternating current.
	Earth (ground) terminal.

Symbol	Description
	Protective conductor terminal.
	Frame or chassis terminal.
	Equipotentiality.
	On (supply).
	Off (supply).
	Equipment protected throughout by double insulation or reinforced insulation.
	In position of a bi-stable push control.
	Out position of a bi-stable push control.

General Requirements for Operating the Equipment

To safely operate electrical equipment in commercial or training environments, the following requirements apply:

- **Follow national regulations** that govern electrical systems and equipment in commercial or industrial facilities.
- **Ensure supervision.** A qualified supervisor (electrician or trained electrical engineer with documented training) must oversee the laboratory or classroom.
- **Perform correct setup.** Install and commission the equipment strictly according to the accompanying documentation before use.
- **Remove damaged equipment.** Immediately block off and remove damaged or defective devices, cables, leads, pneumatic tubing, or hydraulic hoses from the lab or classroom.
- **Ensure the room is equipped with all required safety devices.** Where local regulations apply, the room must include:
  - DC-sensitive residual current devices (RCDs), type B, ≤ 30 mA.
  - Overcurrent protection (circuit breakers or fuses).
  - One or more emergency-off devices to cut power either for the entire room or individual workstations.
  - Security features (e.g., lockable power-on switches or on-off valves) to prevent unauthorized activation of voltage or compressed air.

Use for Intended Purpose

The equipment may only be used:

- For its intended purpose in teaching and training applications.
- When its safety functions are in flawless condition.

The equipment components are designed with the latest technology and adhere to recognized safety standards. However, improper use can endanger the user and others, and may damage the equipment.

The Festo Didactic learning program is designed solely for training. To keep trainees safe, the training company or supervisors must ensure that all trainees use the equipment as instructed in the Festo Didactic courses and follow the safety guidelines in this document.

⚠ WARNING

Risk of danger from using the equipment in a way other than prescribed by Festo Didactic!

- Using the equipment in a way other than directed in the accompanying Festo Didactic courses, or using the equipment with equipment from other manufacturers, may increase the risk of injuries or property damage.
- To minimize the risk of danger, always respect the specifications marked on the equipment as well as the specifications in the Festo Didactic data sheet of the equipment.
- If the equipment includes a third-party component, consult the manufacturer's official documentation for that component—available from the manufacturer or online—to ensure safe use and compliance with all specifications and directives.

Guarantee and Liability

Our "general terms and conditions of sale and delivery" are always applicable. These are made available to the operating company no later than on conclusion of the sales contract. Guarantee and liability claims resulting from personal injury and/or property damage are excluded if they can be traced back to one or more of the following causes:

- Use of the equipment for anything other than its intended purpose.
- Improper commissioning and/or operation of the equipment.
- Use of the equipment with defective safety equipment, or with improperly attached or non-functional safety and protective equipment.
- Non-compliance with instructions included in the core documentation about commissioning and operation.
- Unauthorized modifications to the equipment.
- Improperly executed repairs.
- Disasters resulting from the influence of foreign bodies and acts of nature.

Festo Didactic hereby excludes any and all liability for damages suffered by trainees, the training company, and/or any third parties, which occur during use of the equipment in situations which serve any purpose other than training and/or vocational education, unless such damages have been caused by Festo Didactic due to malicious intent or gross negligence.

Work and Safety Instructions

Safety responsibilities

Responsibilities are divided by role as shown in the following table.

Table 1: Responsibilities by role.

Role	Responsibilities
Operating company	• Allow only qualified personnel to work with the equipment. • Ensure personnel are trained in safety regulations and have read the safety information in this document. • Periodically evaluate personnel for safe working practices.
Instructor	• Supervise trainees at all times. • Permit only harmless mistakes and prevent actions that could cause injury or damage.
Trainees	• Read the safety chapter and warnings before use. • Follow all applicable work-safety and accident-prevention rules. • Work only under the supervision of a qualified person.

General operational safety

⚠ CAUTION

Ignoring basic operational safety rules may lead to accidents, injuries, or equipment damage.

- Trainees must be supervised by an instructor at all times when working with the equipment.
- Use the equipment only as instructed in Festo Didactic documentation.
- Keep switches, buttons, and disconnectors unobstructed and easy to reach.
- Repair or secure faulty equipment immediately.
- Wear suitable personal protective equipment (PPE), such as safety glasses and safety shoes.
- Avoid wearing loose clothing or accessories that could become entangled in equipment.
- Secure long hair to prevent it from interfering with moving parts or obstructing vision.
- Keep the work area clean, dry, and free of substances that could cause slips or interfere with equipment operation.

⚠ CAUTION

Improper handling of heavy equipment may cause personal injury or equipment damage.

- Use proper lifting techniques or assistance when moving heavy components marked with the lifting-hazard symbol.

Personal protective equipment (PPE)

Despite built-in safety features, residual risks remain due to misuse or faulty components. To reduce injury risk, always follow these PPE guidelines:

- Wear **safety shoes** when frequently moving equipment between storage and workstations.
- Wear **safety glasses** when working with polarized capacitors, which may explode unexpectedly.
- Wear **hearing protection** when using noisy equipment such as rotating machines.

- Wear **insulating gloves** when handling live electrical components.
- Wear **safety gloves** for mechanical handling (e.g., sharp edges, heavy parts, hot surfaces).

Equipment handling and layout

NOTICE

Cable handling

- Lay out cables without bends, pinches, or contact with hot surfaces (clearly marked if applicable).
- Always unplug by pulling the plug itself—never pull on the cable.
- Prevent continuous tension on cables to avoid damage and disconnection.

NOTICE

Ventilation and heat management

- Keep all ventilation slots unobstructed. Place equipment only on hard, flame-resistant surfaces to allow proper airflow.
- Do not install heat-generating equipment near or underneath temperature-sensitive components.

NOTICE

Workstation setup

- Check the maximum load capacity of the workstation and ensure it is not exceeded.

Electrical safety

⚠ WARNING

Risk of electric shock due to dangerous voltage

The equipment contains hazardous voltage that can cause death, serious injury, or major property damage if safety instructions are ignored.

Protective earth (PE)

- Always earth equipment fitted with a PE terminal.
- Connect the PE first and disconnect it last.
- Do not break or damage yellow-green PE conductors.
- Equipment with high leakage current needs a separate PE lead on its extra PE terminal.

Prohibited practices

- Never connect power sources in series.
- Never connect multiple power supplies to a single ac power wall outlet, as this can cause higher leakage currents.
- Do not exceed the input voltage or current rating of any device, as this can lead to heating, shocks, and fires.

Safe voltage limits

- Contact with > 30 V ac rms or > 60 V dc can be fatal.
- Shield power source outputs and leads from touch; use shrouded safety leads rated CAT II or higher.
- Switch off all power sources and de-energize circuits before wiring changes.
- Only use detachable mains supply cords, cables, and connection leads with adequate ratings.

Capacitors

- Large capacitors may stay charged after power-off. Wait several minutes before opening housings.

Low-voltage circuits

- Power low-voltage circuits only with Class II SELV or double-insulated supplies (e.g., Festo Didactic power sources).

Cyber security

Festo Didactic provides products with security functions that support the safe operation of plants, systems, machines, and networks. However, protecting these assets from cyber threats requires a comprehensive and regularly updated security concept. Festo's products and services form only part of such a strategy.

The customer is responsible for preventing unauthorized access to their equipment and networks. Connections to company networks or the Internet should be made only when necessary and only with appropriate security measures in place—such as firewalls, network segmentation, and defense-in-depth strategies. Without these measures, connecting products to a network can expose vulnerabilities that allow unauthorized remote access, potentially affecting the entire system. This access can be exploited for data theft, manipulation, or sabotage. Common threats include Denial-of-Service attacks, remote code execution, privilege escalation, ransomware, and other malicious activities. In industrial environments, such attacks can lead to unsafe conditions, endangering people and equipment.

Customers should follow Festo's security guidelines and keep their products up to date. Festo continuously enhances its products for improved security and strongly recommends installing updates promptly. Using outdated or unsupported versions increases exposure to cyber threats.

Help Festo maintain safety by reporting security issues to the Festo Product Security Incident Response Team (PSIRT) in German or English via email at psirt@festo.com or through the online form at https://www.festo.com/psirt.

⚠ WARNING

Unsecure operating conditions due to software tampering

- Software tampering (e.g., viruses, Trojans, malware, worms) can cause unsafe system conditions, potentially leading to serious injury or property damage.
- Keep your software up to date.
- Integrate all automation and actuator components into a comprehensive industrial security concept that reflects current technological standards.
- Ensure all installed products are covered by your security concept.
- Use protective tools, such as antivirus software, to scan files on removable storage media for malware.

Equipment Installation and Commissioning

Environmental requirements

The equipment is designed to be installed and stored indoors and operated in the following environmental conditions:

- An altitude up to 2000 m (6560 ft).
- A temperature between 5°C and 40°C (41°F and 104°F).
- A maximum relative humidity of 80% for temperatures up to 31°C (88°F), decreasing linearly to 50% relative humidity at 40°C (104°F).
- Mains supply voltage fluctuations which do not exceed ±10% of the nominal voltage.
- Transient overvoltages up to the levels of overvoltage category II (1500 V for 120 V mains and 2500 V for 230 V mains).
- Temporary overvoltage occurring on the mains supply.
- A pollution degree of 2 (dry, non-conductive pollution).

The word pollution used above refers to any addition of foreign matter, solid, liquid, or gaseous (ionized gases), that may produce a reduction of dielectric strength or surface resistivity.

Equipment handling

Before handling equipment, ensure the following:

- You know where to install or relocate the equipment.
- The path is clear—no obstacles, bumps, or slippery surfaces.
- You can safely lift and carry the equipment. Check its weight beforehand if needed.

While carrying equipment, make sure to:

- Maintain a firm grip.
- Hold the equipment close to your waist, with level shoulders. Do not extend your arms.
- Move slowly and maintain stable footing.
- Turn by moving your feet, not by twisting your back.

⚠ CAUTION

Physical stress likely to occur when handling heavy equipment.

- Take extra care when lifting or moving heavy equipment.
- Equipment heavier than 5 kg (10 lb) are marked with a lifting hazard symbol where not otherwise obvious.

Equipment installation in an A4 workstation

The equipment is designed either for tabletop use or for installation in an A4 workstation. The following safety guidelines apply when equipment is installed in an A4 workstation.

To install equipment in an A4 workstation, first place the equipment between the lower and upper rails of a workstation row. Then, insert the top edge of the equipment in the upper rail of the workstation row. Finally, insert the bottom edge of the equipment in the lower rails so that the equipment is up straight. Once properly installed, the equipment can slide on the rails.

Always respect the following recommendations when installing equipment in an A4 workstation.

- If the A4 workstation comprises more than one row, equipment that dissipates heat should be installed in the top row. Heat-dissipating equipment are recognized by a hot surface caution sign cut in the top surface of the equipment.
- The manufacturer gives the maximum load limit of the rails of the A4 workstation. It is important to consult the document on the A4 workstation before installing the equipment in order to avoid overloading the rails.

Festo Didactic A4 workstations 8153360 and 8158409 are rated for 50 kg (110 lb) per row.

Protective earthing instructions

Before you power up the equipment, follow these steps to ensure protective earthing (grounding).

Power Source module

- Connect the module into a properly grounded ac outlet.
- Its two PE terminals are now at earth potential and serve as the common earthing point.

Training modules

- Every other module also has two PE terminals.
- Connect them using the supplied PE leads to form strings of up to 20 modules.
- Connect each string to a PE terminal on the Power Source module.

If you use leads other than the ones supplied, they must have a minimum cross-section of 4 mm² (EN 60204-1).

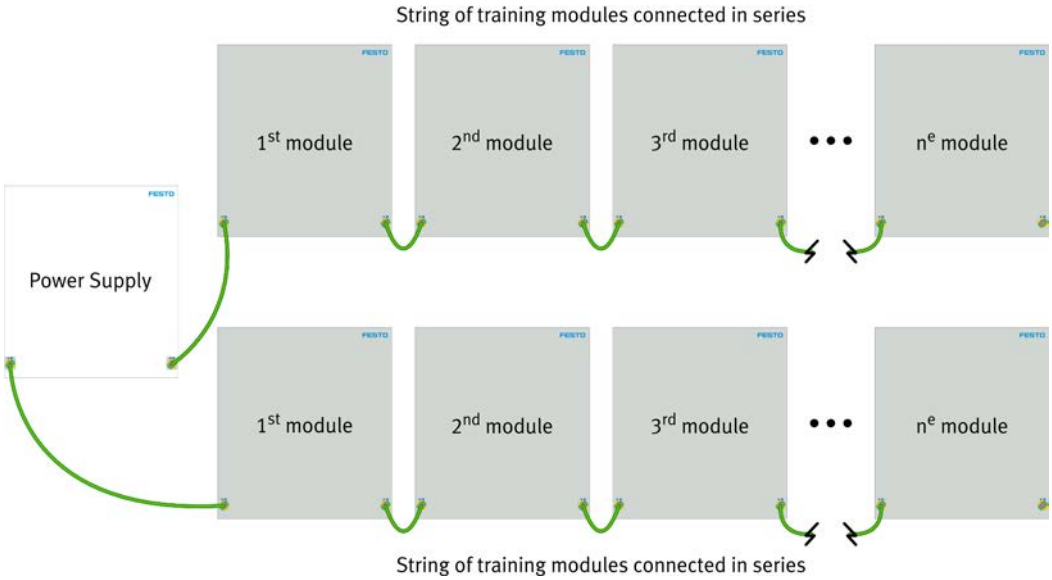

Figure 1: Protective earthing of the training modules in an equipment setup containing a single power supply module.

Quick start

This section provides a quick-start procedure to install and power up the equipment at the beginning of a laboratory exercise or session. This section also provides a general procedure to power off, disconnect, and remove the equipment at the end of a laboratory exercise or session.

Installing and powering up the equipment

1. Make sure that you have read and understood the directives in the Work and Safety Instructions section of this document before you start using the equipment.

2. Install all the modules required for your laboratory exercise in the A4 workstation. Refer to the Equipment handling and Installing equipment in an A4 workstation sections in case of need.

3. Make the connections required for protective earthing of the equipment according to the directives in the Protective earthing instructions section.

4. Make sure that the power supply module is turned off by turning the disconnect safety switch to the OFF position.

   Connect the power supply module to a properly protected ac power outlet.

5. Connect the equipment as required for your laboratory exercise, using the connection leads terminated with safety plugs provided with the equipment.

⚠ WARNING

Do not use connection leads from other manufacturers. Always use the connection leads provided with the equipment to make all connections. The live parts of these leads have their plugs concealed and insulated in such a way that they cannot be contacted accidentally, allowing safe connection of the equipment without danger of electric shock.

6. Verify your equipment connections.

7. Activate the breaker switch (I position).

8. Turn on electric power at your workstation by turning the disconnect safety switch to the ON position.

If necessary, ask the assistance of your supervisor.

⚠ WARNING

When the equipment is powered on, keep in mind the following directives to avoid the risk of injuries caused by electric shocks:

- Never leave the equipment unattended.
- Unless specifically stated otherwise, never modify the equipment connections while power is on.
- Never move a module while power is on.

Powering off, disconnecting, and removing the equipment

1. Turn electric power off at your workstation by turning the disconnect safety switch to the OFF position.

2. Turn the power supply module off by deactivating the breaker switch (O position).

3. Remove all equipment connections, finishing with the protective earthing connections. Return all equipment and connection leads to their storage location.

Equipment Description

The Building HVAC Controls Training System is modular and allows the implementation of several DDC configurations. The following modules are required to complete the exercises in this course: a power source, a transformer, two programmable controllers, a temperature sensor, a supervisory controller, and the HVAC layout.

The power source and transformer modules provide power to all other modules. The power source provides power from the local ac network to the transformer, supervisory controller, and HVAC layout, while the transformer provides 24 V ac power to the programmable controllers.

The HVAC layout is the heart of the system; it simulates building infrastructure (ducts, sensors, heaters, etc.) and allows the variation of environmental variables such as air temperature and pressure. The remaining modules are two identical programmable controllers, a temperature sensor, and a supervisory controller. The following figure shows these modules installed in a workstation.

To simulate the various sensors normally connected to the air-handling unit or controller(s), knobs are available on the HVAC layout. These knobs send input signals to the controllers and simulate parameters such as temperature, air pressure, and CO_2 level variations.

Each of these modules is described in the following subsections.

- Power Source
- Control Transformer
- Building HVAC Layout
- Temperature Network Sensor
- Programmable Controller
- Supervisory Controller

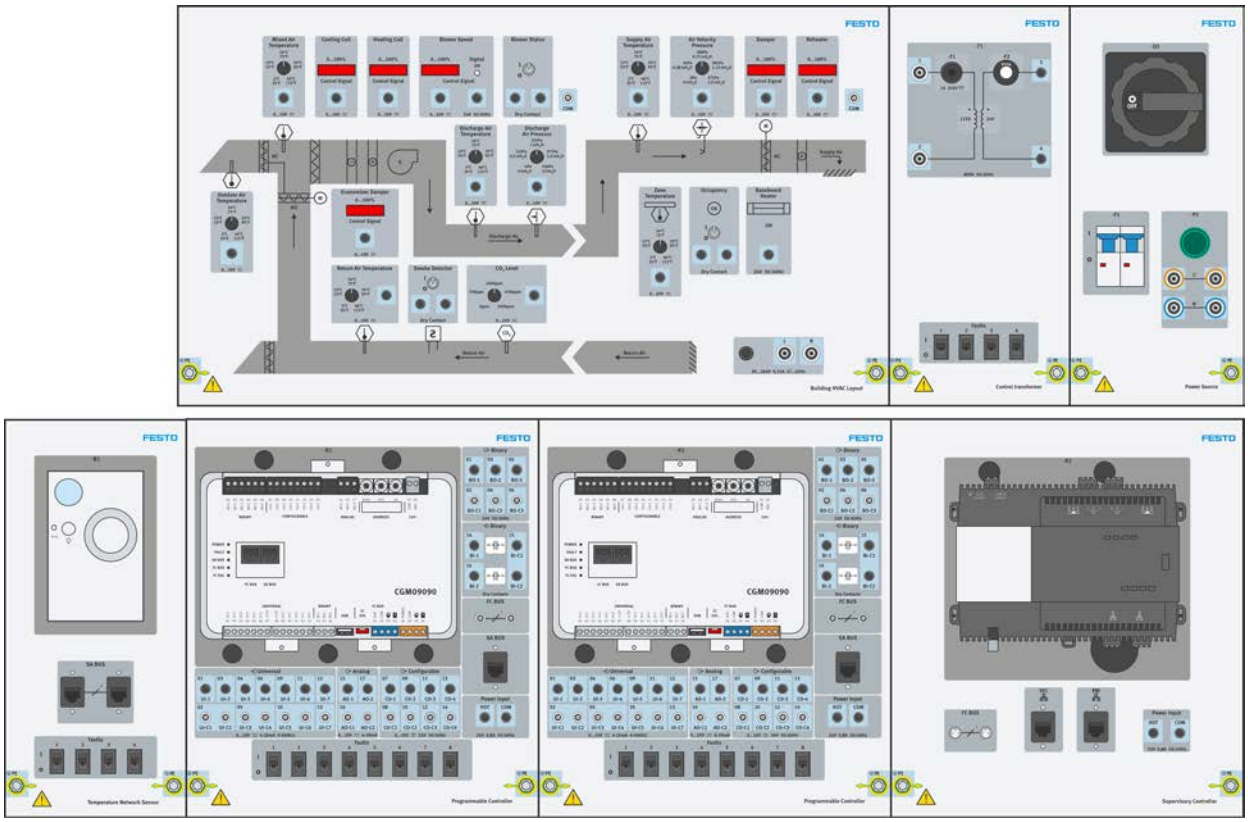

Figure 2: Building HVAC Controls Training System.

The preceding figure includes the following equipment, from left to right:

Top row: HVAC Layout, Control Transformer, Power Source.

Bottom row: Temperature Sensor, Programmable Controller × 2, Supervisory Controller.

Power Source

The power source module connects to a standard wall outlet to provide power to the other modules of the system. The voltage output of the power source depends on the local ac power network voltage. The following figure shows a power source rated for a 230 V ac power network.

A thermal-magnetic circuit breaker provides overcurrent and short-circuit protection. If the intensity of the current flowing from the power source ever reaches a value greater than the breaker current rating for a certain length of time, the circuit breaker opens the circuit, thus preventing damage to the power source and other equipment. To turn power back on, set the breaker disconnect switch to the I position and turn the main power switch on.

When the power source module is on, power is available through the L and N jacks. Use the provided 4 mm test leads to connect the power source to the other devices.

NOTICE

Always verify the power specification of a module before connecting it to the power source.

⚠ WARNING

To reduce the risk of electrical shock in case of malfunction, always connect the ground (green and yellow) terminals of each module in series with the ground terminals of the power source.

The front panel of the 120 V version of the Power Source module is slightly different from the 230 V version.

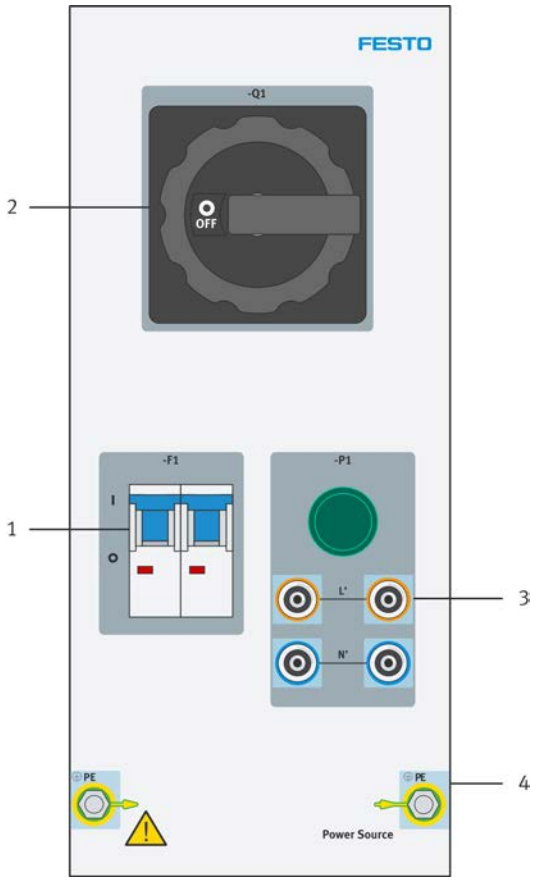

Figure 3: Front panel of the Power Source.

1. Circuit breaker, type C. 10 A if manufactured after 2025-03-04 or 12 A if manufactured before that date.
2. Disconnect safety switch
3. AC power outputs (terminals L' and N'), with power status LED indicator
4. Protective earthing terminals

Table 2: Specifications of the Power Source.

Parameter	Rating
AC power network voltage and frequency	230 V – 50 Hz (594513) 120 V – 60 Hz (594512)
Maximum current	10 A if manufactured after 2025-03-04 or 12 A if manufactured before that date.
Electrical installation	1 phase, including line, neutral, and earth wires, protected by a circuit breaker in accordance with local regulations.
Installation location	Tabletop or A4 workstation
Ingress protection rating	IP20
Electromagnetic compatibility	Group 1, Class A (industrial environment, EN 55011)
Dimensions (H × W × D)	298 × 150 × 140 mm (11.7 × 5.9 × 5.5")
Weight	2.4 kg (5.3 lb)
CE and UKCA markings	• Low-Voltage Directive • EMC Directive • RoHS Directive

Control Transformer

The control transformer module (see the following figure) decreases the line voltage from the power source down to a voltage of 24 V, which is required by several modules of the training system. To obtain the required voltage at the secondary winding, be sure to connect the primary winding of transformer to a power supply that match the control transformer specifications.

NOTICE

Never apply more than the rated voltage to the transformer terminals.

The connections to the primary winding of the control transformer are made through 4 mm test leads (high voltage), and the connections to the secondary winding are made through 2 mm test leads (low voltage). Fuses protect the primary and secondary windings.

This module is also equipped with four fault switches and two ground terminals. Each fault is described in the instructor version of the courseware related to the equipment.

The front panel of the 120 V version of the Control Transformer is slightly different from the 230 V version.

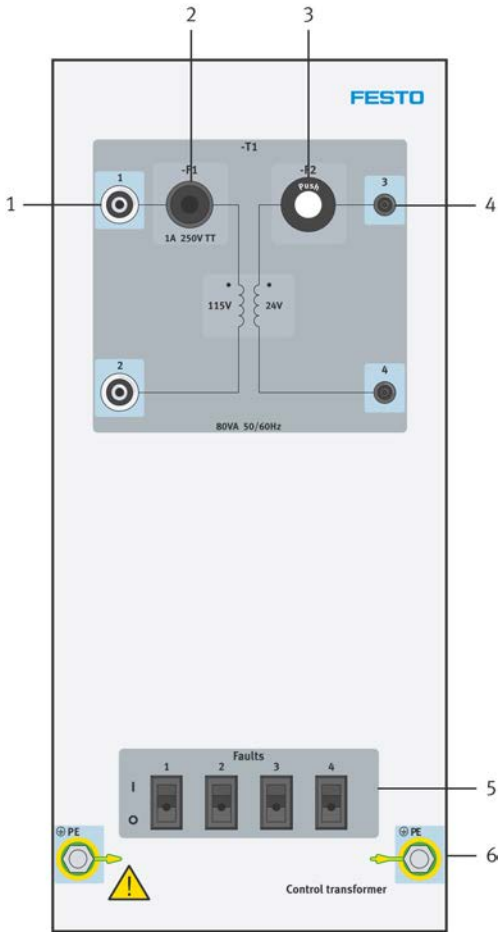

Figure 4: Front panel of the Control Transformer.

1. Primary winding terminals (terminals 1 and 2)
2. Primary winding overcurrent protection
3. Secondary winding overcurrent protection
4. Secondary winding terminals (terminals 3 and 4)
5. Fault switches
6. Protective earthing terminals

Table 3: Specifications of the Control Transformer.

Parameter	Rating 230 V – 50/60 Hz (594515)	Rating 120 V – 60 Hz (594514)
Power rating	80 VA	
Input voltage and frequency	230 V – 50/60 Hz	120 V – 60 Hz
Input current	0.5 A	1.0 A
Output voltage and frequency	24 V ac – 50/60 Hz	24 V ac – 60 Hz
Output current	3.15 A	3.0 A, 250 V
Primary winding overcurrent protection	0.5 A, 250 V	1.0 A, 250 V
Secondary winding overcurrent protection	3.15 A, 250 V	3.0 A, 250 V
Installation location	Tabletop or A4 workstation	
Ingress protection rating	IP20	
Electromagnetic compatibility	Group 1, Class A (industrial environment, EN 55011)	
Dimensions (H × W × D)	298 × 150 × 140 mm (11.7 × 5.9 × 5.5")	
Weight	2.9 kg (6.4 lb)	
CE and UKCA markings	• Low-Voltage Directive • EMC Directive • RoHS Directive	

Building HVAC Layout

The HVAC layout of the Building HVAC Controls Training System represents the infrastructure of a building to which the programmable controller(s) connect. The faceplate of this module can be divided into two regions, as shown in the following figure.

The first section represents the air-handling unit and the various temperature and pressure sensors. Buttons and connectors related to a particular device or section of the diagram are usually located close to that device or section. For example, the mixed air temperature button is located close to the representation of the temperature sensor on the faceplate. Adjusting the different buttons allows you to simulate the output signals sent by the different sensors normally available in a building HVAC system. 2 mm leads relay the output signals from the simulated sensors to the controller module.

All the I/O blocks are either: digital input, analog output, analog input, or dry contact. Only the Blower Speed block features both an analog input and a digital input.

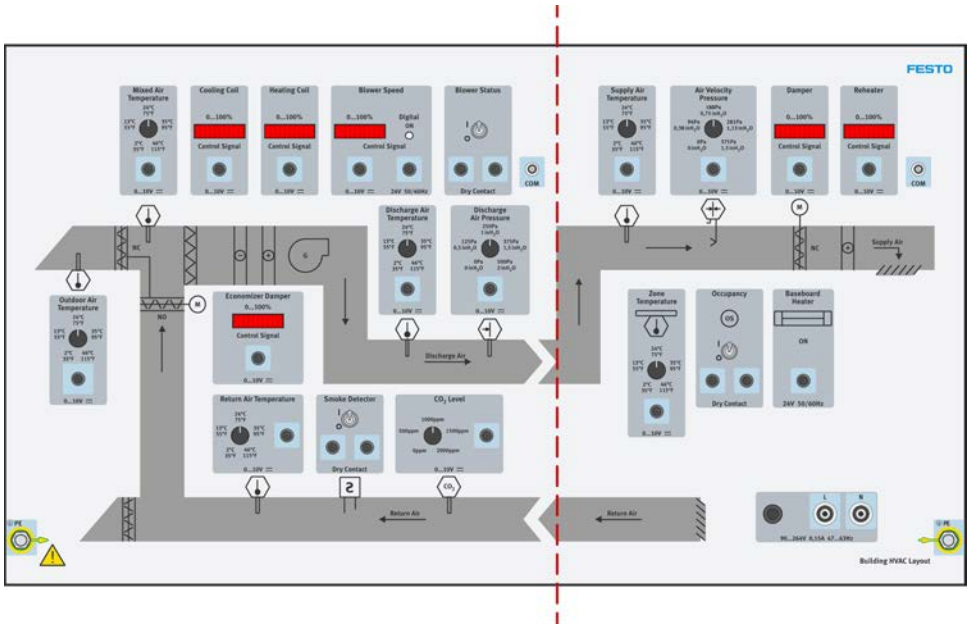

Figure 5: Building HVAC Layout.

The following figure shows the components in the first section of the HVAC layout and identifies the main components, described below. Further information regarding the various components of the HVAC layout is provided as required by the exercises in this course.

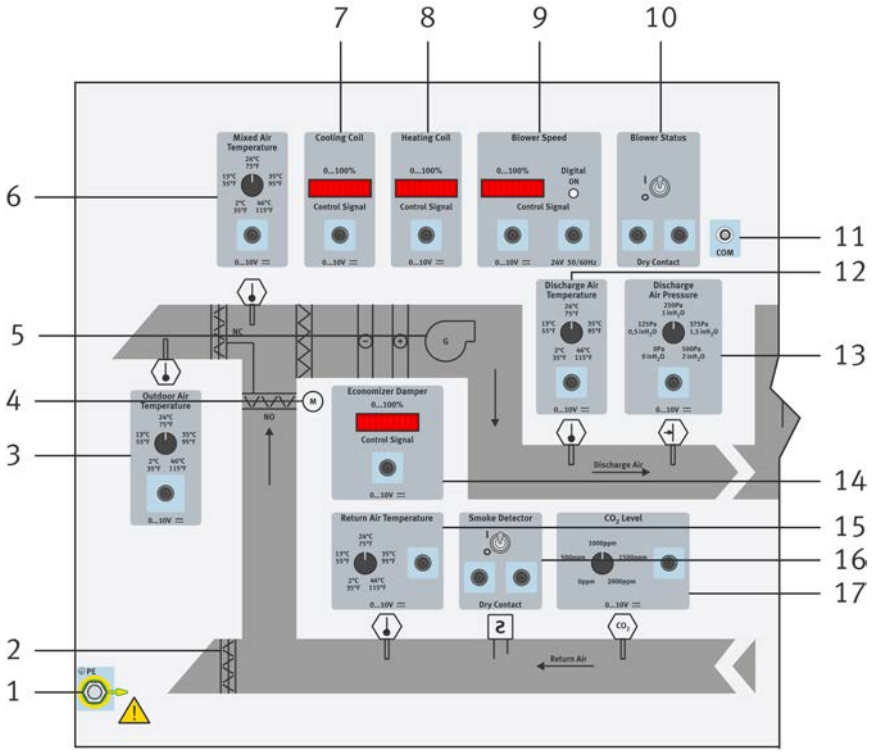

Figure 6: Building HVAC Layout – Air-handling unit section.

1. Protective earthing terminal

2. Exhaust damper

3. Outdoor Air Temperature

   - The terminal provides a 0-10 V dc analog output for the simulated temperature sensor of the outdoor air.
   - The button sets the simulated outdoor air temperature.

4. Return damper

5. Blower

6. Mixed Air Temperature

   - The terminal provides a 0-10 V dc analog output for the simulated temperature sensor of the mixed air.
   - The button sets the simulated air temperature in the mixed air section.

7. Cooling Coil. 0–10 V dc input controls the cooling coil. A bar meter shows the control level:
    - 10 bars: maximum cooling
    - 0 bar: no cooling

8. Heating Coil. 0–10 V dc input controls the heating coil. A bar meter shows the control level:
    - 10 bars: maximum heating
    - 0 bar: no heating

9. Blower speed
    - Analog input: 0–10 V dc blower control signal. A bar meter indicates blower speed:
        - 10 bars: full speed
        - 0 bar: blower stopped
    - Digital input: 24 V ac blower control signal. A green LED indicates blower operation.

10. Blower Status
    - The dry contact terminals indicate blower status:
        - Switch in I position: contact closed (blower running).
        - Switch in O position: contact open (blower stopped).
    - The switch simulates a sensor detecting blower operation.

11. Common terminal

12. Discharge Air Temperature
    - The terminal provides a 0-10 V dc analog output for the simulated temperature sensor of the air supply.
    - The button sets the simulated air temperature in the supply duct.

13. Discharge Air Pressure
    - The terminal provides a 0-10 V dc analog output for the simulated pressure sensor of the air supply.
    - The button sets the simulated air pressure in the supply duct.

14. Economizer Damper. 0–10 V dc input controls the economizer damper. A bar meter shows the signal level:

    - 10 bars: NC damper fully open
    - 0 bar: NC damper fully closed

    The NO return damper closes as the signal increases due to mechanical linkage.

15. Return Air Temperature

    - The terminal provides a 0-10 V dc analog output for the simulated temperature sensor of the return air.
    - The button sets the simulated air temperature in the return duct.

16. Smoke Detector

    - The dry contact terminals indicate smoke detector status:
        - Switch in I position: contact closed (smoke detected).
        - Switch in O position: contact open (no smoke).
    - The switch simulates the smoke detector state.

17. CO_2 Level

    - The terminal provides a 0-10 V dc analog output for the simulated CO_2 level sensor.
    - The switch simulates the CO_2 level sensor output.

The second section of the HVAC layout represents the infrastructure of the building, including the zone damper, reheater, zone sensors, and baseboard heater. LEDs and bar meters indicate the status of the different elements. 2 mm leads relay the output signals from the simulated sensors to the controller module.

The following figure shows the section and identifies the main components, described below.

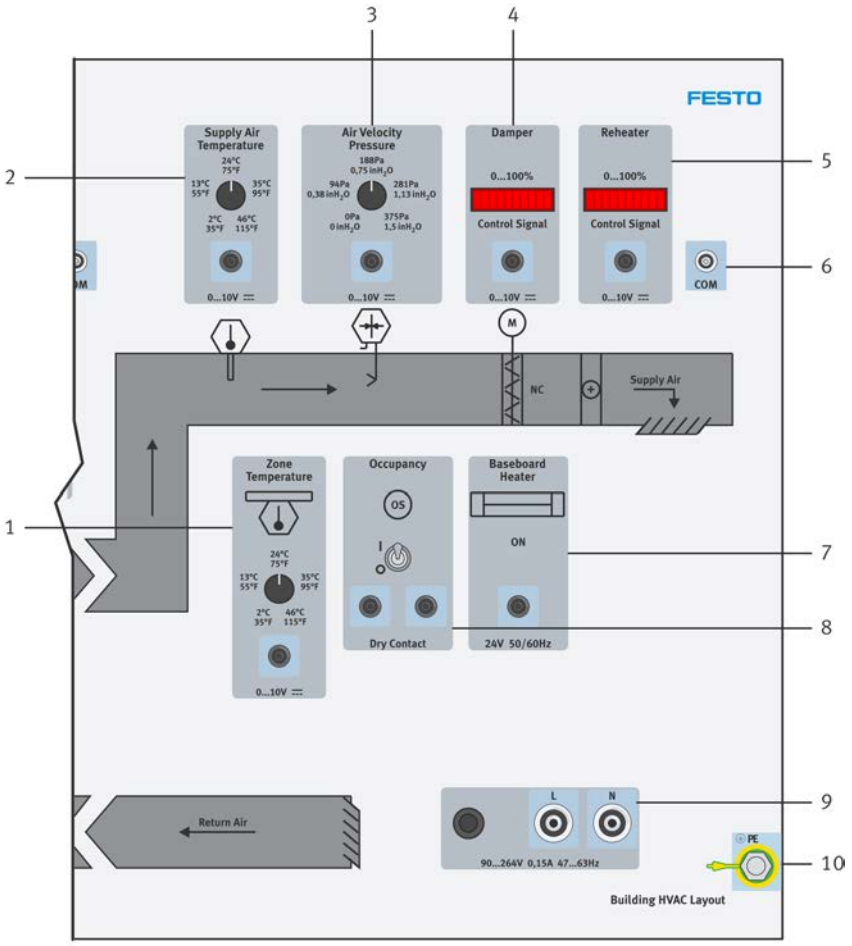

Figure 7: Building HVAC Layout – zone section.

1. Zone Temperature

   - The terminal provides a 0-10 V dc analog output for the simulated zone temperature sensor.
   - The button sets the simulated temperature in the zone.

2. Supply Air Temperature

   - The terminal provides a 0-10 V dc analog output for the simulated supply air temperature sensor.
   - The button sets the simulated supply air temperature.

3. Air Velocity Pressure

   - The terminal provides a 0-10 V dc analog output for the simulated air velocity pressure sensor.
   - The button sets the simulated air velocity pressure (0 Pa to 375 Pa or 0 inH_2O to 1.5 inH_2O).

4. Damper. 0–10 V dc input controls the damper. A bar meter shows the signal level:
    - 10 bars: damper fully open
    - 0 bar: damper fully closed

5. Reheater. 0–10 V dc input controls the reheater. A bar meter shows the control level:
    - 10 bars: maximum heating
    - 0 bar: no heating

6. Common terminal

7. Baseboard Heater. The terminal provides a digital input (24 V ac) for the control signal for the baseboard heater. A green LED indicates that the baseboard heater is on.

8. Occupancy
    - The dry contact terminals indicate occupancy:
        - I position: contact closed (zone occupied)
        - O position: contact open (zone unoccupied)
    - The switch simulates an occupancy sensor.

9. Line and neutral terminals from the power source

10. Protective earthing terminal

The humidity control plate shown in the following figure can be affixed to the HVAC layout of the Building HVAC Controls Training System to enable experimentations in humidity control of a CAV HVAC system. It adds the following two functions:

- **Zone Humidity**
    - The terminal provides a 0-10 V dc analog output for the simulated zone humidity sensor.
    - The button sets the simulated relative humidity in the zone.

- **Humidifier**
  0–10 V dc input controls the humidifier. A bar meter shows the control level:
    - 10 bars: full operation
    - 0 bar: off

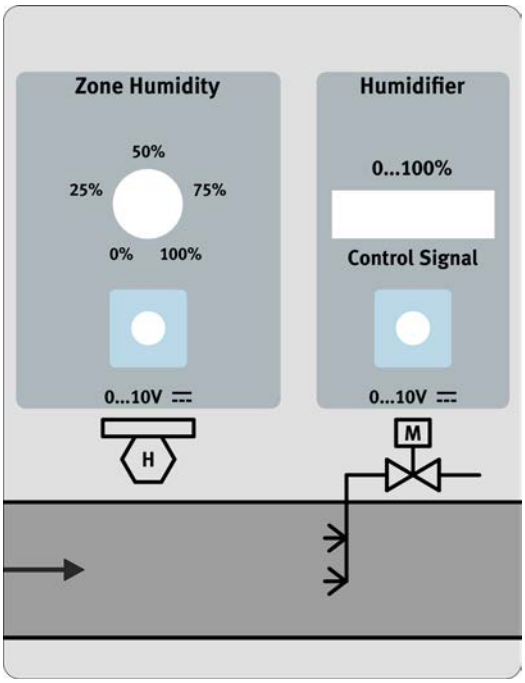

Figure 8: Humidity control plate.

Table 4: Specifications of the Building HVAC Layout.

Parameter	Rating
Input voltage and frequency	100 V to 240 V at 50/60 Hz
Current	0.15 A
Installation location	Tabletop or A4 workstation
Ingress protection rating	IP20
Electromagnetic compatibility	Group 1, Class A (industrial environment, EN 55011)
Dimensions (H × W × D)	298 × 530 × 140 mm (11.7 × 20.9 × 5.5")
Weight	4.7 kg (10.4 lb)
CE and UKCA markings	• Low-Voltage Directive • EMC Directive • RoHS Directive

Temperature Network Sensor

The temperature sensor module shown in the following figure is usually networked with similar sensors to provide temperature information to the building controller(s). It is also used to adjust the temperature set point. Although this sensor is equipped with an internal temperature sensor, it is only used in this manual to send set point information to a controller. The temperature is provided to the controller via the HVAC layout. For this reason, only the terminals required for powering the sensor and for set point information are available. The wiring of this sensor is done using special cables with RJ12 connectors.

The temperature sensor module is also equipped with four fault switches and two ground terminals. Each fault is described in the instructor version of the courseware related to the equipment.

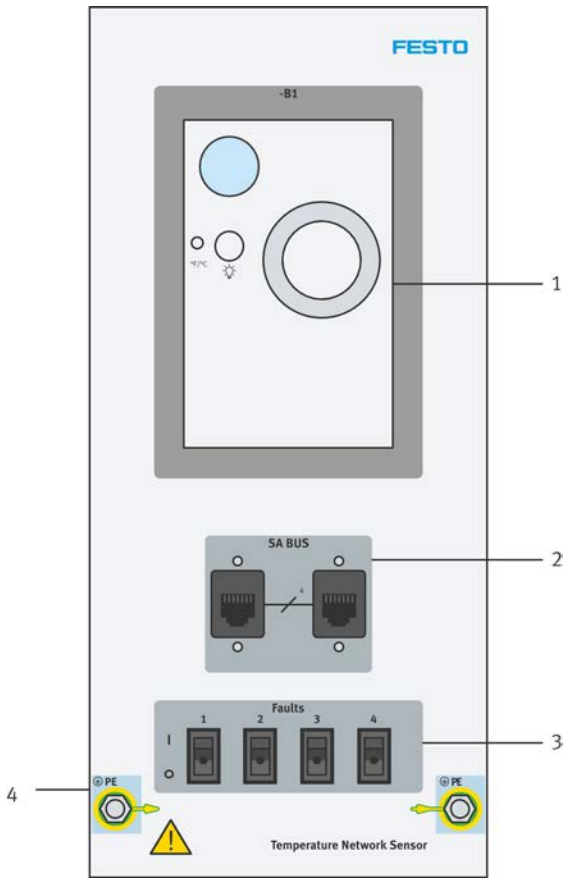

Figure 9: Front panel of the Temperature Network Sensor.

1. Temperature sensor
2. SA bus jacks
3. Fault switches
4. Protective earthing terminals

Table 5: Specifications of the Temperature Network Sensor.

Parameter	Rating
Installation location	Tabletop or A4 workstation
Ingress protection rating	IP20
Electromagnetic compatibility	Group 1, Class A (industrial environment, EN 55011)
Dimensions (H × W × D)	298 × 150 × 140 mm (11.7 × 5.9 × 5.5")
Weight	1.6 kg (3.5 lb)
CE and UKCA markings	• Low-Voltage Directive • EMC Directive • RoHS Directive

Programmable Controller

The main distinguishing feature of a DDC HVAC system in comparison to a “classic” HVAC system is the type of controller it uses. The programmable controller shown in the following figure is a typical controller found in DDC systems. It has different types of inputs. These inputs receive signals from external devices such as sensors. The controller treats these signals according to the programmed logic, then sends signals to the appropriate devices connected to the controller outputs.

The programmable controllers are general purpose controllers. Each device has the same hardware, but can be programmed for a specific task. For example, a controller can be programmed to control a zone in a building, while another controller of the same type can be programmed to control an air-handling unit. This is a great advantage of programmable controllers over HVAC controllers, which have a fix logic and can only be configured.

The programmable controller module must be powered using a 24 V ac source, provided by the secondary windings of the control transformer module.

The programmable controller module has six universal inputs, two binary inputs, two analog outputs, three binary outputs, and four configurable outputs. The logic of the controller determines how the inputs and outputs are used. The general characteristics of the inputs and outputs are given in the following table.

A sensor/actuator bus (SA bus) and a field controller bus (FC bus) are also available on the controller. Both require a special cable for connection. The SA bus is used for connection to sensors such as a temperature sensor. The FC bus, on the other hand, is used for connection to a supervisory controller, allowing commissioning or programming using a computer.

The programmable controller module is also equipped with eight fault switches and two ground terminals. Each fault is described in the instructor version of the courseware related to the equipment.

Table 6: Programmable controller inputs and outputs.

Type of input/output	Quantity	Description
Universal input	6	Can be used either as an analog input or a binary input. When used as an analog input, the following modes are available: • voltage mode (0-10 V dc) • current mode (4-20 mA) • resistive mode (0-2 kΩ)
Binary input	2	Can be used as a dry contact in maintained mode or as a pulse counter.
Analog output	2	Two modes are available for an analog output: • voltage mode (0-10 V dc) • current mode (4-20 mA)
Binary output	3	24 V ac triac
Configurable output	4	Can be used either as an analog output (0-10 V dc) or as a binary output (24 V ac triac).

The front panel of the Programmable Controller (594516) is shown in the following figure.

1. Protective earthing terminals
2. Fault switches
3. Universal inputs
4. Analog outputs
5. Programmable controller
6. DIP switches
7. Binary outputs
8. Binary inputs (dry contacts)
9. FC bus terminals
10. SA bus socket
11. Configurable outputs
12. Power input (24V and COM)

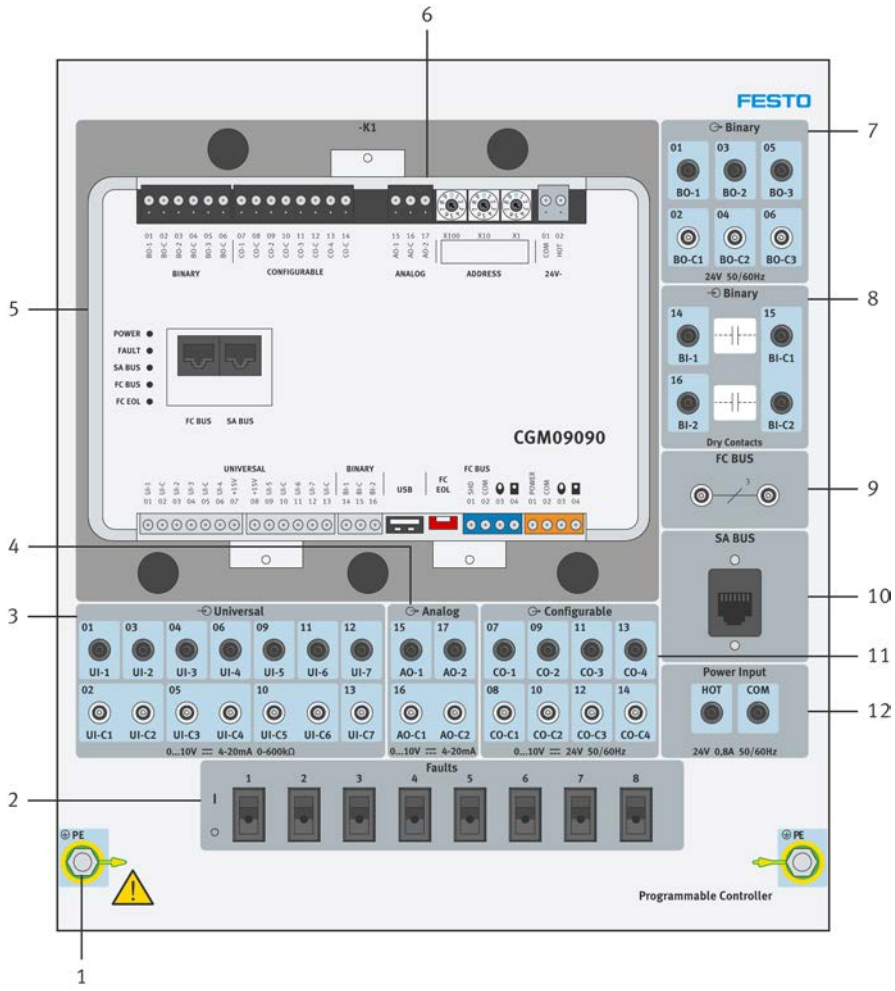

Figure 10: Front panel of the Programmable Controller (594516).

The front panel of the Programmable Controller (8216205) is shown in the following figure.

1. Protective earthing terminals
2. Fault switches
3. Universal inputs
4. Analog outputs
5. Programmable controller
6. Rotary switch block
7. Binary outputs
8. Binary inputs (dry contacts)
9. FC bus terminals
10. SA bus socket
11. Configurable outputs
12. Power input (24V and COM)

For more information, consult the manufacturer's documentation for General Purpose Application Controllers (CGM) at Johnson Controls.

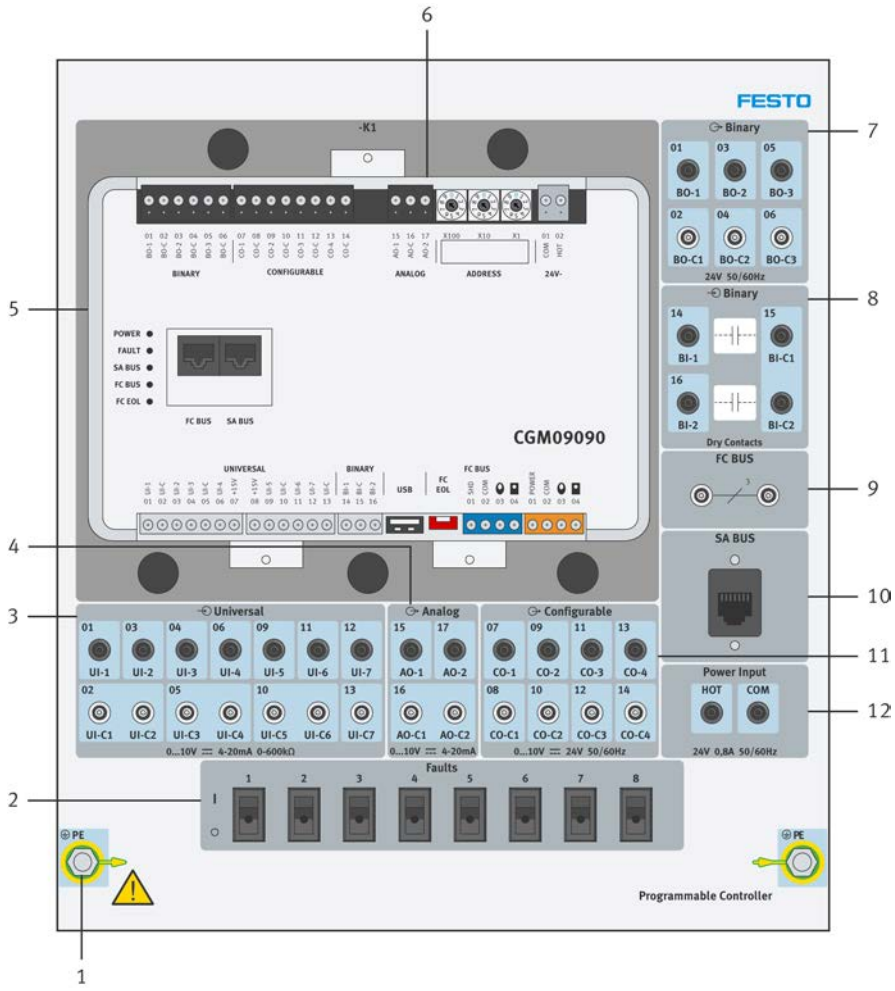

Figure 11: Front panel of the Programmable Controller (8216205).

Table 7: Specifications of the Programmable Controller (594516 and 8216205).

Parameter	Rating
Installation location	Tabletop or A4 workstation
Ingress protection rating	IP20
Electromagnetic compatibility	Group 1, Class A (industrial environment, EN 55011)
Dimensions (H × W × D)	298 × 265 × 140 mm (11.7 × 10.4 × 5.5")
Weight	3.0 kg (6.6 lb)
CE and UKCA markings	• Low-Voltage Directive • EMC Directive • RoHS Directive

Supervisory Controller

The supervisory controller can be used to access the configuration and status of the controller(s) from a remote computer. This type of device is typically used by technicians to troubleshoot HVAC systems (using a laptop computer, for example). In the case of the supervisory controller shown below, any device connected to the controller can access a SCADA interface via a web browser (see the following figure).

Figure 12: SCADA interface main window.

The supervisory controller module must be powered using the local ac power network voltage, obtained from the power source module. The supervisory controller has M8 connectors to connect it to devices like programmable controllers via an FC bus.

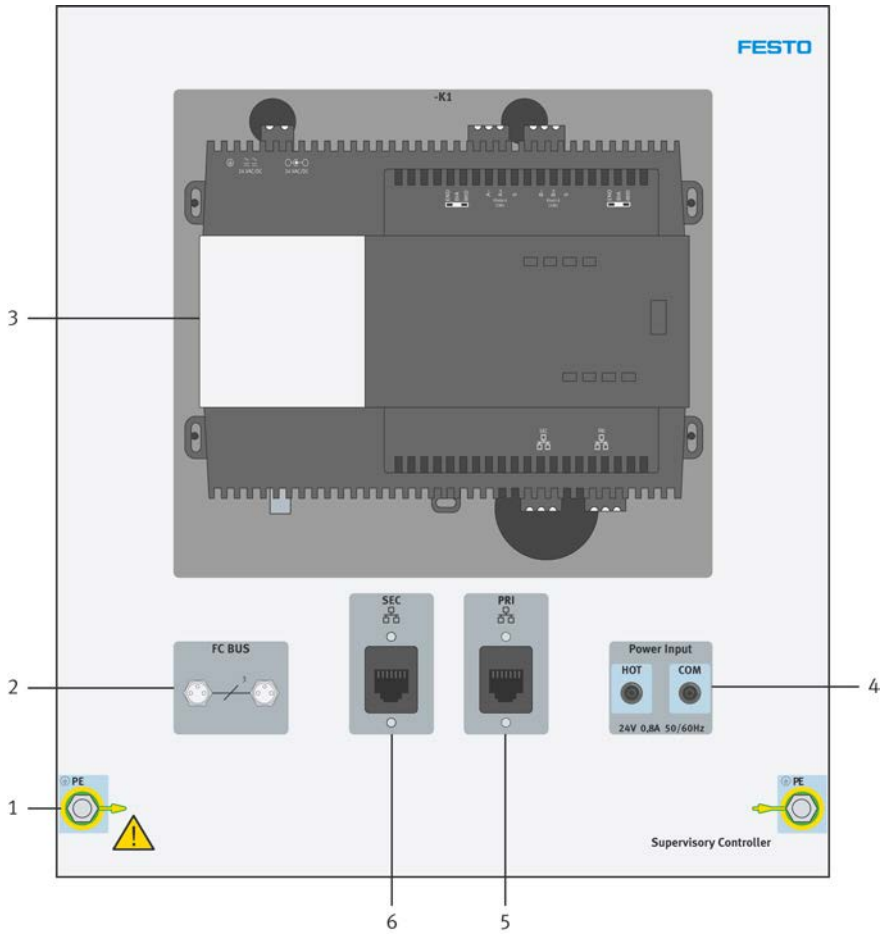

Figure 13: Front panel of the Supervisory Controller FX-SC9BASE-0.

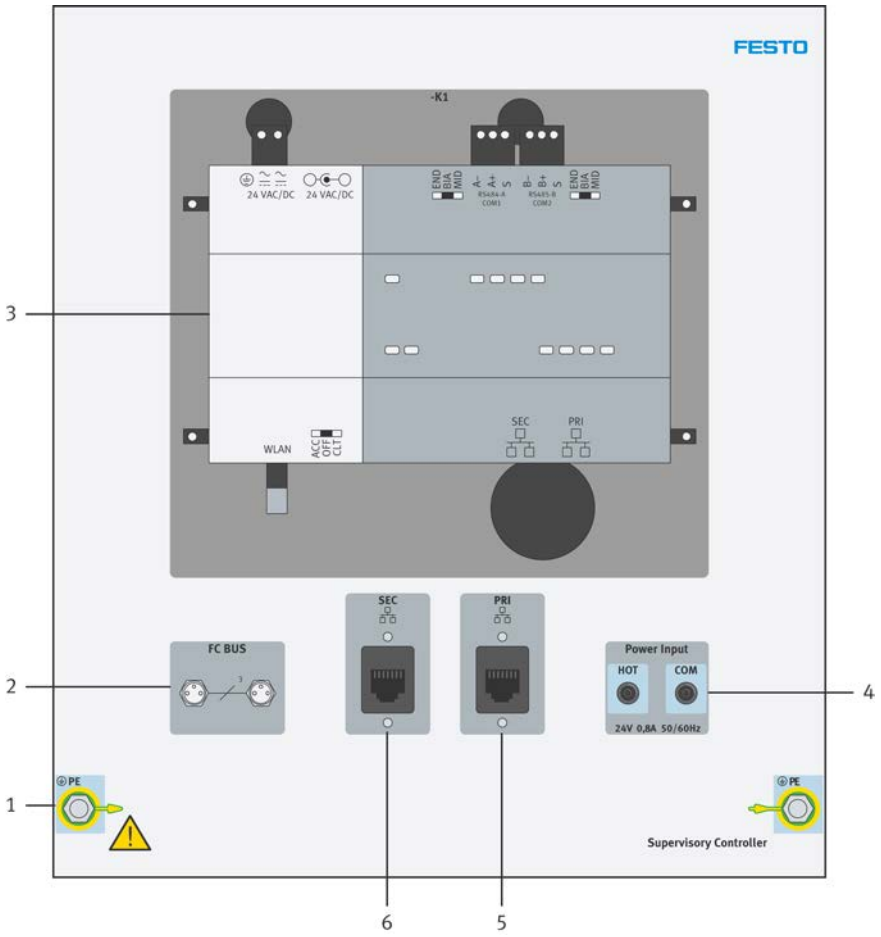

Figure 14: Front panel of the Supervisory Controller FX-SC8BASE-0 (earlier model).

1. Protective earthing terminals
2. FC bus terminals
3. Supervisory controller
4. Power input (24V and COM)
5. Primary Ethernet port
6. Secondary Ethernet port

Table 8: Specifications of the Supervisory Controller.

Parameter	Rating
Installation location	Tabletop or A4 workstation
Ingress protection rating	IP20
Electromagnetic compatibility	Group 1, Class A (industrial environment, EN 55011)
Dimensions (H × W × D)	298 × 265 × 140 mm (11.7 × 10.4 × 5.5")
Weight	2.8 kg (6.2 lb)
CE and UKCA markings	• Low-Voltage Directive • EMC Directive • RoHS Directive

Equipment Maintenance

The equipment is designed to ensure user safety, reliability, and effective learning outcomes. To maintain safety and performance, it is important to keep the equipment in good condition.

The learning system needs regular maintenance. Students will perform some tasks as part of their training, while qualified personnel must handle other periodic maintenance.

Since trainees may not yet detect issues, a technician or instructor should inspect the system before and after each use.

Replace defective or missing components immediately. Contact our service department for replacement parts and instructions.

⚠ CAUTION

- Instructors and laboratory personnel must communicate these directions and guidelines to students, as they are essential for maintaining the equipment's safety and functionality.
- Do not operate the equipment with missing or damaged parts.

General maintenance

The equipment does not require any particular maintenance. However, it is very important to perform a visual inspection of the equipment before each laboratory exercise. If a piece of equipment appears damaged or shows wear, it must be replaced to ensure user safety and prevent further damage to the equipment.

There are no user serviceable parts inside the equipment, other than certain parts that may need to be replaced, such as fuses, button cells, batteries, etc. Opening or removing the equipment housing to replace parts may expose you to dangerous voltages. Do not try to open the equipment housing to replace parts. Have a qualified technician replace parts in the equipment.

Consumables and replacement parts

It is possible to replace certain pieces of equipment that are consumable or that have been damaged. Use only Festo Didactic parts and accessories to ensure compatibility and sustainability of the equipment. Available replacements parts and accessories are listed below.

Table 9: List of consumable pieces and damageable equipment.

Part	Type	Rating	Order no.
Connection leads			
Connection lead	4 mm safety laboratory cables	500 mm	793137
	2 mm safety laboratory cables	100 mm	793134
		500 mm	793135
		1000 mm	793136
Protective earthing leads			
Protective earthing lead	4 mm² protective earth cable	100 mm	8067504
		400 mm	8067505
Control Transformer (594514)			
Fuse	5×20 mm, IEC 60127-2 Time-Lag Fuse	1.0 A, 250 V	792467
Fuse	5×20 mm, IEC 60127-2 Time-Lag Fuse	3.15 A, 250 V	791941
Control Transformer (594515)			
Fuse	5×20 mm, IEC 60127-2 Time-Lag Fuse	0.5 A, 250 V	791934
DDC Controller (594516 or 8216205)			
CD Resources DDC	CD		793132
Safety and Commissioning Document on USB Stick	USB Stick		793131

Part	Type	Rating	Order no.
Cable with M8 connectors	3-pin M8 connector	Male-male, 0.5 m	793133
Cable with M8 connectors	3-pin M8 connector	Male-female, 1.5 m	8078284
Temperature Network Sensor (594517)			
Cable Patch	RJ12	0.6 m	765714
Layout HVAC (594518)			
Optional Replacement Panel	Room Humidity and Damper Control Display for the Layout module		792540
Supervisory Controller (594519)			
Patch Cable	RJ45, Cat 5e	1.8 m	775147

NOTICE

- Before replacing a blown fuse, identify and correct the problem that caused the overcurrent.
- Replace a blown fuse with a fuse of the exact same type. Using the wrong type of fuse may cause damage to the equipment or cause injury.

Equipment modification

Do not modify the equipment without prior written permission of Festo Didactic. The equipment was designed in accordance with various regulations (safety, electromagnetic compatibility, etc.). Modifications could have undesired consequences on product integrity and safety.

The use or installation of spare parts by unqualified persons, as well as any repair or modifications not complying with the product's original specifications and manufacturing methods, can cause material damage, serious injury, or even death. It may also void any warranty or product approval.

Equipment disposal

Do not discard the equipment with normal waste: it contains electrical and electronic components. A specialist must dismantle the product. Each component must be recycled or disposed of according to your local legislation.

It is the owner's responsibility to make provisions for the equipment recycling and safe disposal.

Waste from Electrical and Electronic Equipment (WEEE) directive:

- In accordance with European regulations, used electrical and electronics devices cannot be disposed of in unsorted municipal waste. The symbol of the waste bin on wheels indicates the necessity for separate collection. For environmental protection, make sure the equipment is disposed of in the waste sorting processes designed for this purpose. DIRECTIVE 2012/19/EU of the EUROPEAN PARLIAMENT AND OF the COUNCIL of 4 July 2012 on waste electrical and electronic equipment (WEEE).

The presence of this symbol on the equipment indicates the necessity of separate collection.

Cleaning

To clean the front panel(s) and housing(s) of the equipment, use a soft cloth and a mild solution of detergent and water. It is important not to apply the solution directly onto the surface of the equipment. Instead, apply the solution onto the soft cloth.

NOTICE
Unless specifically stated otherwise, do not use abrasive substances or solvents to clean any part of the equipment.

Indications of conformity

Directives and declarations of conformity

The directives applicable to each piece of equipment in the learning system are specified in the corresponding Equipment Description section.

You can download declarations of conformity for all available equipment using the following link:

1. Enter your equipment name in the search field.
2. Click the "Didactic Products" tab.
3. Select your equipment from the search results.
4. Open the "Downloads" tab.
5. Go to the "Certificates" section.
6. Download the required documents.

Festo website.

https://www.festo.com

Electromagnetic compatibility (EMC)

The following table outlines international electromagnetic compatibility (EMC) compliance requirements, specifying applicable standards, equipment classifications, and usage limitations.

Table 10: Electromagnetic compatibility (EMC) compliance.

International	EN IEC 61326-1: Basic Electromagnetic Environment CISPR 11: Group 1 or 2 (see the Equipment Description section for precision on each piece of equipment), Class A ● Group 1: Equipment covered by this standard that is not classified as Group 2. Group 2: Industrial, scientific, and medical radio-frequency (ISM RF) equipment that intentionally generates or uses radio-frequency energy (9 kHz to 400 GHz), locally applied via electromagnetic radiation, inductive or capacitive coupling, for purposes such as material treatment, inspection, analysis, or energy transfer. ● Class A: Equipment is suitable for use in all establishments other than domestic and those directly connected to a low-voltage power supply network that supplies buildings used for domestic purposes. There may be potential difficulties in ensuring electromagnetic compatibility in other environments due to conducted and radiated disturbances. ● Caution: This equipment is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.

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User Guide

Building HVAC

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