

4 Quadrant Power Supply and Dynamometer Controller

FESTO

Electric Power Technology

User Guide

230 V - 50 Hz



Electricity and New Energy

4 Quadrant Power Supply and Dynamometer Controller

User Guide

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By the staff of Festo Didactic

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

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Safety and Common Symbols

The following safety and common symbols may be used in this manual and on the equipment:

Symbol	Description
	DANGER indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
	WARNING indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
	CAUTION indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
	CAUTION used without the <i>Caution, risk of danger</i> sign  , indicates a hazard with a potentially hazardous situation which, if not avoided, may result in property damage.
	Caution, risk of electric shock
	Caution, hot surface
	Caution, risk of danger. Consult the relevant user documentation.
	Caution, lifting hazard
	Caution, belt drive entanglement hazard
	Caution, chain drive entanglement hazard
	Caution, gear entanglement hazard
	Caution, hand crushing hazard
	Notice, non-ionizing radiation
	Consult the relevant user documentation.
	Direct current
	Alternating current
	Both direct and alternating current
	Three-phase alternating current
	Earth (ground) terminal

Safety and Common Symbols









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

Table of Contents

About This Manual	VII
1 4 Quadrant Power Supply and Dynamometer Controller	1
1.1 Power Supply mode	1
1.2 Dynamometer mode.....	1
1.3 Control mode.....	1
1.3.1 Set up procedure for Manual control operation	3
1.3.2 Setup procedure for Computer-Based control operation	4
1.4 Function set activation procedure	7
1.5 Language configuration	7
1.6 Unit settings.....	8
1.7 Torque automatic calibration procedure	8
1.8 Friction compensation calibration procedure	10
1.9 Function description (Power Supply operating mode)	13
1.10 Function description (Dynamometer operating mode)	16
1.11 Specifications.....	20

About This Manual

Safety considerations

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

Make sure that you are wearing appropriate protective equipment when using the system. You should never use the equipment if you have any reason to think that a manipulation could be dangerous.

1 4 Quadrant Power Supply and Dynamometer Controller

The [4 Quadrant Power Supply and Dynamometer Controller](#) is a highly versatile USB peripheral designed to be used in the Electric Power Technology Training System. Two operating modes are available: Power Supply and Dynamometer.

In each operating mode, a wide variety of user-selectable functions is available, and the key parameters related to the selected function are displayed. Optional functions can be added to the standard functions to further enhance the training possibilities of the [4 Quadrant Power Supply and Dynamometer Controller](#). Among them are a small wind turbine emulator, a hydraulic turbine emulator, a solar panel emulator, battery chargers, and a software development kit (SDK).

The [4 Quadrant Power Supply and Dynamometer Controller](#) is powered from a standard wall receptacle via a line cord that connects to the module's front panel. The module helps energy conservation by returning the mechanical or electrical energy it receives to the ac power network while maintaining a unity power factor.

1.1 Power Supply mode

In the Power Supply mode, the unit acts as a four-quadrant power supply. Various functions allow different types of electric power sources, such as a variable dc voltage source, a variable dc current source, or a variable-voltage and variable-frequency ac power source to be implemented. In this operating mode, the key parameters displayed are voltage, current, electrical power, and energy. Two safety banana jacks on the module front panel provide access to the power supply terminals. Optional functions like a battery charger/discharger, a solar panel emulator, and a software development kit (SDK) are also available for the Power Supply mode.

To operate in the Power Supply mode, the *Operating Mode* switch of the [4 Quadrant Power Supply and Dynamometer Controller](#) must be set to *Power Supply*.

1.2 Dynamometer mode

In the Dynamometer mode, the unit act as a four-quadrant dynamometer. Various functions allow the unit to act as either a fully configurable brake (i.e., a mechanical load), or a fully configurable prime mover (i.e., a motor drive). In this operating mode, the key parameters displayed are speed, torque, mechanical power, and energy. There are other optional functions like a small wind-turbine emulator or a hydraulic-turbine emulator for the Dynamometer mode.

When operating in the Dynamometer mode, the [4 Quadrant Power Supply and Dynamometer Controller](#) must be connected to the [4 Quadrant Dynamometer Motor](#). Also, the *Operating Mode* switch of the [4 Quadrant Power Supply and Dynamometer Controller](#) must be set to *Dynamometer*.

1.3 Control mode

The functions performed by the [4 Quadrant Power Supply and Dynamometer Controller](#) can be controlled in two modes: Manual mode or Computer-Based mode.

In the Manual mode, the module operates as a stand-alone unit (without the use of a computer). The function performed is selected, set, and monitored using front-panel mounted controls and display. This mode provides access to all basic functions.

The *Command* knob on the front panel of the 4 Quadrant Power Supply and Dynamometer Controller allows the main parameter of the selected function to be set. Table 1 indicates the parameter that is set for each function available when the 4 Quadrant Power Supply and Dynamometer Controller operates in the Power Supply mode.

Parameters	Value
Voltage source (+)	Voltage
Voltage source (-)	Voltage
Current source (+)	Current
Current source (-)	Current
50 Hz power source	Voltage
60 Hz power source	Voltage
200 V dc bus	None

Table 1. Parameter that can be adjusted using the *Command* knob when the 4 Quadrant Power Supply and Dynamometer Controller operates in the Power Supply mode.

Table 2 indicates the parameter that is set for each function available when the 4 Quadrant Power Supply and Dynamometer Controller operates in the Dynamometer mode.

Parameter	Value
Two-quadrant constant-torque brake (2QCT)	Torque
Clockwise (CW) prime mover/brake	Speed
Counterclockwise (CCW) prime mover/brake	Speed
Clockwise constant-speed (CW-CS) prime mover/brake	Speed
Counterclockwise constant-speed (CCW CS) prime mover/brake	Speed
Positive constant-torque (CT) prime mover/brake	Torque
Negative constant-torque (CT) prime mover/brake	Torque

Table 2. Parameter that can be adjusted using the *Command* knob when the 4 Quadrant Power Supply and Dynamometer Controller operates in the Dynamometer mode.

In the Computer-Based mode, the function performed by the module is selected, set, and monitored using the LVDAC-EMS software. In this mode, communication between the 4 Quadrant Power Supply and Dynamometer Controller and the host computer running the LVDAC-EMS software is achieved through a USB connection. This mode provides access to all basic functions, as well as to additional advanced functions.

Refer to the user guide entitled "Computer-Based Instruments for EMS" to learn how to install the LVDAC-EMS software for use with the 4 Quadrant Power Supply and Dynamometer Controller.

1.3.1 Set up procedure for Manual control operation

Perform the procedure below to install, connect, and power up the 4 Quadrant Power Supply and Dynamometer Controller for Manual control operation.

1. Install the 4 Quadrant Power Supply and Dynamometer Controller in the workstation.
2. If you are using the 4 Quadrant Power Supply and Dynamometer Controller in the Power Supply mode, set the *Operating Mode* switch to the *Power Supply* position then go to step 6 of this procedure. Otherwise, go to the next step of the procedure.
3. You are using the 4 Quadrant Power Supply and Dynamometer Controller in the Dynamometer mode. Set the *Operating Mode* switch to the *Dynamometer* position.

Place the 4 Quadrant Dynamometer Motor on a horizontal surface near the workstation.

Observe that there is an identification (ID) label on the 4 Quadrant Power Supply and Dynamometer Controller as well as on the 4 Quadrant Dynamometer Motor. For optimal operation, the ID of the 4 Quadrant Dynamometer Motor should be the same as the ID of the 4 Quadrant Power Supply and Dynamometer Controller.

Install a rotating machine beside the 4 Quadrant Dynamometer Motor. The rotating machine and the 4 Quadrant Dynamometer Motor must be placed side-to-side if you are using timing belt coupling, or face-to-face if you are using direct coupling.

Refer to guide Safety Instructions and Commissioning of the Electric Power Technology Training Equipment for information on how to properly position the 4 Quadrant Dynamometer Motor and the rotating machine.

4. Connect the cable on the 4 Quadrant Dynamometer Motor to the 4 Quadrant Power Supply and Dynamometer Controller.

Mechanically couple the 4 Quadrant Dynamometer Motor to the rotating machine.

Refer to guide Safety Instructions and Commissioning of the Electric Power Technology Training Equipment for information on how to properly couple the 4 Quadrant Dynamometer Motor to a rotating machine.

5. Install the protective guard on the 4 Quadrant Dynamometer Motor and the rotating machine. This guard is intended to avoid possible injuries resulting from accidental contact with the shaft of

the [4 Quadrant Dynamometer Motor](#) or rotating machine. Operation of the [4 Quadrant Dynamometer Motor](#) and rotating machine is prevented when the guard is not installed.

Refer to guide [Safety Instructions and Commissioning of the Electric Power Technology Training Equipment](#) for information on how to properly install the protective guard on the [4 Quadrant Dynamometer Motor](#) and the rotating machine.

6. Make the connections required to properly earth the equipment.

Refer to guide [Safety Instructions and Commissioning of the Electric Power Technology Training Equipment](#) for information on how to properly earth the equipment.

7. Make sure that the main power switch on the [4 Quadrant Power Supply and Dynamometer Controller](#) is set to the *O* (off) position, and then connect its *Power Input* to an ac power outlet that is properly protected.

Refer to guide [Safety Instructions and Commissioning of the Electric Power Technology Training Equipment](#) for information on how to make sure that the ac power outlet to which you connect the [4 Quadrant Power Supply and Dynamometer Controller](#) is properly protected.

8. Turn on (i.e., unlock) electric power at your workstation, if applicable.

If necessary, ask the assistance of your supervisor.

9. Turn the [4 Quadrant Power Supply and Dynamometer Controller](#) on by setting the *Power Input* switch to the *I* (on) position.

You are now ready to perform manipulations with the [4 Quadrant Power Supply and Dynamometer Controller](#) operating in the Manual control mode.

1.3.2 Setup procedure for Computer-Based control operation

Before performing the procedure below, make sure that the latest version of software [LVDAC-EMS](#) is installed on your computer. Software [LVDAC-EMS](#) is available on the Festo Didactic website. You can verify that you have the latest version of software [LVDAC-EMS](#) by selecting [Check for Update](#) in the [Help](#) menu of the software.

Perform the procedure below to install, connect, and power up the [4 Quadrant Power Supply and Dynamometer Controller](#) for Computer-Based control operation using the [LVDAC-EMS](#) software.

1. Install the [4 Quadrant Power Supply and Dynamometer Controller](#) in the workstation.

2. If you are using the **4 Quadrant Power Supply and Dynamometer Controller** in the Power Supply mode, set the *Operating Mode* switch to *Power Supply* then go to step 6 of the procedure. Otherwise, go to the next step of the procedure.
3. You are using the **4 Quadrant Power Supply and Dynamometer Controller** in the Dynamometer mode. Set the *Operating Mode* switch to the *Dynamometer* position.

Place the **4 Quadrant Dynamometer Motor** on a horizontal surface near the workstation.

Observe that there is an identification (ID) label on the **4 Quadrant Power Supply and Dynamometer Controller** as well as on the **4 Quadrant Dynamometer Motor**. For optimal operation, the ID of the **4 Quadrant Dynamometer Motor** should be the same as the ID of the **4 Quadrant Power Supply and Dynamometer Controller**.

Install a rotating machine beside the **4 Quadrant Dynamometer Motor**. The rotating machine and the **4 Quadrant Dynamometer Motor** must be placed side-to-side if you are using timing belt coupling or face-to-face if you are using direct coupling.

Refer to guide Safety Instructions and Commissioning of the Electric Power Technology Training Equipment for information on how to properly position the **4 Quadrant Dynamometer Motor** and the rotating machine.

4. Connect the cable on the **4 Quadrant Dynamometer Motor** to the **4 Quadrant Power Supply and Dynamometer Controller**.

Mechanically couple the **4 Quadrant Dynamometer Motor** to the rotating machine.

Refer to guide Safety Instructions and Commissioning of the Electric Power Technology Training Equipment for information on how to properly couple the **4 Quadrant Dynamometer Motor** to a rotating machine.

5. Install the protective guard on the **4 Quadrant Dynamometer Motor** and the rotating machine. This guard is intended to avoid possible injuries resulting from accidental contact with the shaft of the **4 Quadrant Dynamometer Motor** or rotating machine. Operation of the **4 Quadrant Dynamometer Motor** and rotating machine is prevented when the guard is not installed.

Refer to guide Safety Instructions and Commissioning of the Electric Power Technology Training Equipment for information on how to properly install the protective guard on the **4 Quadrant Dynamometer Motor** and the rotating machine.

6. Make the connections required to properly earth the equipment.

Refer to guide Safety Instructions and Commissioning of the Electric Power Technology Training Equipment for information on how to properly earth the equipment.

7. Make sure the *Power Input* switch of the **4 Quadrant Power Supply and Dynamometer Controller** is set to the *O* (off) position, and then connect its *Power Input* to an ac power outlet that is properly protected.

Refer to guide Safety Instructions and Commissioning of the Electric Power Technology Training Equipment for information on how to make sure that the ac power outlet to which you connect the **4 Quadrant Power Supply and Dynamometer Controller** is properly protected.

8. Turn on (i.e., unlock) electric power at your workstation, if applicable.

If necessary, ask the assistance of your supervisor.

9. Connect the USB port of the **4 Quadrant Power Supply and Dynamometer Controller** to a USB port of the host computer.
10. Turn the host computer on then wait while it completes its start-up routine. Turn the **4 Quadrant Power Supply and Dynamometer Controller** on by setting the *Power Input* switch to the *I* (on) position.

If the **4 Quadrant Power Supply and Dynamometer Controller** connects to the host computer for the first time, a message indicating that a new USB peripheral is recognized should appear on the screen. This message should also appear when the **4 Quadrant Power Supply and Dynamometer Controller** connects to the host computer for the first time in DFU mode. The **LVDAC-EMS** software indicates when to switch the module to DFU mode.

If a message appears indicating that the installation of the peripheral has failed, restart the **4 Quadrant Power Supply and Dynamometer Controller** by setting its *Power Input* switch to the *O* (off) position, then setting it back to the *I* (on) position.

11. Start the **LVDAC-EMS** software.

In the **LVDAC-EMS Start-Up** window, make sure the **4 Quadrant Power Supply and Dynamometer Controller** is detected. Make sure that all function sets activated in the **4 Quadrant Power Supply and Dynamometer Controller** are available. Select the network voltage and frequency that correspond to the voltage and frequency of your local ac power network. Then click the **OK** button to close the **LVDAC-EMS Start-Up** window.

At this point, a message may indicate that the firmware in the **4 Quadrant Power Supply and Dynamometer Controller** needs to be updated before using the unit. Follow the instructions indicated on the screen to complete the firmware update.

You are now ready to perform manipulations with the [4 Quadrant Power Supply and Dynamometer Controller](#) operating in the Computer-Based control mode.

1.4 Function set activation procedure

When you buy a new function set for the [4 Quadrant Power Supply and Dynamometer Controller](#), you must activate this function set by performing the procedure below.

1. Perform the procedure in section *Setup procedure for Computer-Based control operation* of this manual.
2. In the *Tools* menu of the [LVDAC-EMS](#) window, select *Activate Function Set*. This will bring up the *Select File* dialog box.
3. In the *Select File* dialog box, find the DFU file (file_name.dfu) you received with the new function set(s) to be activated. This DFU file is necessary for activating the new function set(s). Select this file, which will bring up the *Prepare to Upgrade* dialog box.

Each DFU file required for activating new function set(s) has a specific serial number. This means that a DFU file can only activate new function set(s) on the [4 Quadrant Power Supply and Dynamometer Controller](#) whose serial number corresponds to the serial number in the name of the DFU file. The serial number is indicated on the enclosure of the [4 Quadrant Power Supply and Dynamometer Controller](#).

4. Follow the on-screen instructions to activate the new function set(s) in the [4 Quadrant Power Supply and Dynamometer Controller](#).

You will have to restart both the [4 Quadrant Power Supply and Dynamometer Controller](#) and the [LVDAC-EMS](#) software for the new function set(s) to become available.

1.5 Language configuration

The [4 Quadrant Power Supply and Dynamometer Controller](#) can display text, parameters, and messages on its LCD display in any of the following languages: English, French, German, or Spanish.

Perform the following procedure to configure the language setting of the [4 Quadrant Power Supply and Dynamometer Controller](#). The [4 Quadrant Power Supply and Dynamometer Controller](#) must be in the Computer-Based control mode to perform this procedure.

1. Perform the procedure in section *Setup procedure for Computer-Based control operation* of this manual.
2. In [LVDAC-EMS](#), open the [Four-Quadrant Dynamometer/Power Supply](#) window.
3. In the *Tools* menu of the [Four-Quadrant Dynamometer/Power Supply](#) window, select *Module Configuration*. This will bring up the *Module Configuration* dialog box.

4. In the *Module Configuration* dialog box, scroll through the *Language* drop-down list to select the language setting you want to apply to the 4 Quadrant Power Supply and Dynamometer Controller. Click on the *OK* button to apply the language selected.

1.6 Unit settings

The parameter values shown on the LCD display of the 4 Quadrant Power Supply and Dynamometer Controller can be expressed in any of the following four ways:

- SI (International System of Units);
- SI (International System of Units) with mechanical power expressed in horsepower (hp);
- Imperial system;
- Imperial system with mechanical power expressed in watts (W).

Perform the following procedure to select the units used in the 4 Quadrant Power Supply and Dynamometer Controller. The 4 Quadrant Power Supply and Dynamometer Controller must be in the Computer-Based control mode to perform this procedure.

1. Perform the procedure in section *Setup procedure for Computer-Based control operation* in this manual.
2. In *LVDAC-EMS*, open the *Four-Quadrant Dynamometer/Power Supply* window.
3. In the *Tools* menu of the *Four-Quadrant Dynamometer/Power Supply* window, select *Module Configuration*. This will bring up the *Module Configuration* dialog box.
4. In the *Module Configuration* dialog box, scroll through the *Units* drop-down list to select the units you want to be used in the 4 Quadrant Power Supply and Dynamometer Controller. Click on the *OK* button to apply the units selected.

1.7 Torque automatic calibration procedure

The 4 Quadrant Power Supply and Dynamometer Controller measures torque when it operates in the Dynamometer mode. The *Torque-Auto Calibration* function in software *LVDAC-EMS* optimizes the accuracy of torque measurement achieved in the 4 Quadrant Power Supply and Dynamometer Controller. To do so, the function takes into account the actual magnetic characteristics of the 4 Quadrant Dynamometer Motor connected to the 4 Quadrant Power Supply and Dynamometer Controller.

Perform the following procedure to optimize the accuracy of torque measurement achieved in the 4 Quadrant Power Supply and Dynamometer Controller for the 4 Quadrant Dynamometer Motor to which it is connected.

This procedure is intended to maintain the best possible accuracy of torque measurement over time. Consequently, the procedure only needs to be performed from time to time (e.g., once a year).

1. Install the 4 Quadrant Power Supply and Dynamometer Controller in the workstation. Set the *Operating Mode* switch to the *Dynamometer* position.
2. Place the 4 Quadrant Dynamometer Motor on an horizontal surface near the workstation.

Connect the cable on the **4 Quadrant Dynamometer Motor** to the **4 Quadrant Power Supply and Dynamometer Controller**.

3. Install the protective guard on the **4 Quadrant Dynamometer Motor**. This guard is intended to avoid possible injuries resulting from accidental contact with the shaft of the **4 Quadrant Dynamometer Motor**. Operation of the **4 Quadrant Dynamometer Motor** is prevented when the guard is not installed.

Refer to guide *Safety Instructions and Commissioning of the Electric Power Technology Equipment* for information on how to properly install the protective guard on the **4 Quadrant Dynamometer Motor**.

4. Connect the protective earthing (*PE*) terminal of the **4 Quadrant Dynamometer Motor** to one of the *PE* terminals of the **4 Quadrant Power Supply and Dynamometer Controller**.
5. Make sure that the *Power Input* switch of the **4 Quadrant Power Supply and Dynamometer Controller** is set to the *O* (off) position, and then connect its *Power Input* to an ac power outlet that is properly protected.

Refer to guide *Safety Instructions and Commissioning of the Electric Power Technology Equipment* for information on how to make sure that the ac power outlet to which you connect the **4 Quadrant Power Supply and Dynamometer Controller** is properly protected.

6. Turn on (i.e., unlock) electric power at your workstation, if applicable.

If necessary, ask the assistance of your supervisor.

7. Connect the USB port of the **4 Quadrant Power Supply and Dynamometer Controller** to a USB port of the host computer.
8. Turn the host computer on then wait while it completes its start-up routine.
9. Turn the **4 Quadrant Power Supply and Dynamometer Controller** on by setting the *Power Input* switch to the *I* (on) position.
10. Start the **LVDAC-EMS** software.

In the **LVDAC-EMS Start-Up** window, make sure that the **4 Quadrant Power Supply and Dynamometer Controller** is detected. Make sure that all function sets activated in the **4 Quadrant Power Supply and Dynamometer Controller** are available. Select the network voltage and frequency that correspond to the voltage and frequency of your local ac power network. Then, click the *OK* button to close the **LVDAC-EMS Start-Up** window.

11. In **LVDAC-EMS**, open the **Four-Quadrant Dynamometer/Power Supply** window.

12. In the *Tools* menu of the *Four-Quadrant Dynamometer/Power Supply* window, select *Torque Auto-Calibration*.

The *Torque Auto-Calibration* dialog box should open.

13. Enter the value of inertia of the *4 Quadrant Dynamometer Motor* in the data entry field of the *Torque Auto-Calibration* dialog box. The value of inertia of the *4 Quadrant Dynamometer Motor* is indicated on a label affixed to the unit.

Click the *OK* button in the *Torque Auto-Calibration* dialog box.

A message box should appear indicating that you are about to start the Torque Auto-Calibration process. Make sure that the protective guard is properly installed on the *4 Quadrant Dynamometer Motor* then click the *OK* button to start the Torque Auto-Calibration process. The *4 Quadrant Dynamometer Motor* should start to rotate.

14. When the Torque Auto-Calibration process is finished, a message box should appear asking if you wish to update the torque measurement parameters stored in the firmware of the *4 Quadrant Power Supply and Dynamometer Controller*. Click the *Yes* button to update the torque measurement parameters and close the message box.

The accuracy of torque measurement achieved in the *4 Quadrant Power Supply and Dynamometer Controller* is now optimized for the *4 Quadrant Dynamometer Motor* to which it is connected. These two modules are now paired up.

A set of lettered adhesive labels (included with the *4 Quadrant Dynamometer Motor*) is provided to clearly identify modules that are paired up. Apply adhesive labels bearing the same letter in the identification (ID) area located on the *4 Quadrant Power Supply and Dynamometer Controller* and the *4 Quadrant Dynamometer Motor*.

15. In *LVDAC-EMS*, close the *Four-Quadrant Dynamometer/Power Supply* window.
16. Close *LVDAC-EMS*.
17. Turn the *4 Quadrant Power Supply and Dynamometer Controller* off by setting the *Power Input* switch to the *O* (off) position.
18. Remove all equipment connections.

1.8 Friction compensation calibration procedure

When the *4 Quadrant Power Supply and Dynamometer Controller* operates in the Dynamometer mode, it automatically compensates for the torque produced by friction in the *4 Quadrant Dynamometer Motor* and friction in the mechanical coupling to the rotating machine under study. For example, when the *4 Quadrant Power Supply and Dynamometer Controller* and the *4 Quadrant Dynamometer Motor* operate as a constant-torque prime mover, the torque produced by the prime mover is slightly higher than the torque command. The magnitude of the friction compensation applied primarily depends on the specific *4 Quadrant Dynamometer Motor* and the type of mechanical coupling (timing belt coupling or direct coupling) that are used, as well as on the rotation speed.

Before using the [4 Quadrant Power Supply and Dynamometer Controller](#) and the [4 Quadrant Dynamometer Motor](#) with a specific rotating machine, you should perform the friction compensation calibration procedure described below to ensure that the friction compensation is optimally calibrated for the current operating conditions. When performing the friction compensation calibration procedure, the [4 Quadrant Dynamometer Motor](#) must be coupled to a [Zero Friction Machine](#) using the same type of mechanical coupling (timing belt coupling or direct coupling) that will be used with the rotating machine later on.

1. Install the [4 Quadrant Power Supply and Dynamometer Controller](#) in the workstation. Set the *Operating Mode* switch to the *Dynamometer* position.

Place the [4 Quadrant Dynamometer Motor](#) on a horizontal surface near the workstation.

Observe that there is an identification (ID) label on the [4 Quadrant Power Supply and Dynamometer Controller](#) as well as on the [4 Quadrant Dynamometer Motor](#). For optimal operation, the ID of the [4 Quadrant Dynamometer Motor](#) should be the same as the ID of the [4 Quadrant Power Supply and Dynamometer Controller](#).

Install the [Zero Friction Machine](#) beside the [4 Quadrant Dynamometer Motor](#). The [Zero Friction Machine](#) and the [4 Quadrant Dynamometer Motor](#) must be placed side-to-side if you are using timing belt coupling or face-to-face if you are using direct coupling.

Refer to guide *Safety Instructions and Commissioning of the Electric Power Technology Training Equipment* for information on how to properly position the [4 Quadrant Dynamometer Motor](#) and a rotating machine.

2. Connect the cable on the [4 Quadrant Dynamometer Motor](#) to the [4 Quadrant Power Supply and Dynamometer Controller](#).

Mechanically couple the [4 Quadrant Dynamometer Motor](#) to the [Zero Friction Machine](#).

Refer to guide *Safety Instructions and Commissioning of the Electric Power Technology Training Equipment* for information on how to properly couple the [4 Quadrant Dynamometer Motor](#) to a rotating machine.

3. Install the protective guard on the [4 Quadrant Dynamometer Motor](#) and the [Zero Friction Machine](#). This guard is intended to avoid possible injuries resulting from accidental contact with the shaft of the [4 Quadrant Dynamometer Motor](#) or [Zero Friction Machine](#). Operation of the [4 Quadrant Dynamometer Motor](#) is prevented when the guard is not installed.

Refer to guide *Safety Instructions and Commissioning of the Electric Power Technology Training Equipment* for information on how to properly install the protective guard on the [4 Quadrant Dynamometer Motor](#) and a rotating machine.

4. Make the connections required to properly earth the equipment.

Refer to guide Safety Instructions and Commissioning of the Electric Power Technology Training Equipment for information on how to properly earth the equipment.

5. Make sure that the *Power Input* switch on the *4 Quadrant Power Supply and Dynamometer Controller* is set to the *O* (off) position, and then connect its *Power Input* to an ac power outlet that is properly protected.

Refer to guide Safety Instructions and Commissioning of the Electric Power Technology Training Equipment for information on how to make sure that the ac power outlet to which you connect the *4 Quadrant Power Supply and Dynamometer Controller* is properly protected.

6. Turn on (i.e., unlock) electric power at your workstation, if applicable.

If necessary, ask the assistance of your supervisor.

7. Connect the USB port of the *4 Quadrant Power Supply and Dynamometer Controller* to a USB port of the host computer.

8. Turn the host computer on then wait until it completes its start-up routine.

Turn the *4 Quadrant Power Supply and Dynamometer Controller* on by setting the *Power Input* switch to the *I* (on) position.

9. Start the LVDAC-EMS software.

In the *LVDAC EMS Start-Up* window, make sure that the *4 Quadrant Power Supply and Dynamometer Controller* is detected. Make sure that all function sets activated in the *4 Quadrant Power Supply and Dynamometer Controller* are available. Select the network voltage and frequency that correspond to the voltage and frequency of your local ac power network. Then, click the *OK* button to close the *LVDAC-EMS Start-Up* window.

10. In *LVDAC-EMS*, open the *Four-Quadrant Dynamometer/Power Supply* window.

11. In the *Tools* menu of the *Four-Quadrant Dynamometer/Power Supply* window, select *Friction Compensation Calibration*.

The *Friction Compensation Calibration* dialog box should open.

12. Click the *OK* button in the *Friction Compensation Calibration* dialog box.

A message box should appear indicating that you are about to start the Friction Compensation Calibration process. Make sure that the protective guard is properly installed on the *4 Quadrant Dynamometer Motor* and the *Zero Friction Machine* then click the *OK* button to start the Friction

Compensation Calibration process. The 4 Quadrant Dynamometer Motor and the Zero Friction Machine should start to rotate.

13. Wait for the 4 Quadrant Dynamometer Motor and the Zero Friction Machine to stop rotating.

Remove the protective guard from the 4 Quadrant Dynamometer Motor and the Zero Friction Machine.

Remove the mechanical coupling between the 4 Quadrant Dynamometer Motor and the Zero Friction Machine.

Remove the Zero Friction Machine from the work surface.

14. Restart the 4 Quadrant Power Supply and Dynamometer Controller by turning it off then turning it back on. The friction compensation curve stored in the 4 Quadrant Power Supply and Dynamometer Controller is now optimally calibrated for the current operating conditions.

The 4 Quadrant Power Supply and Dynamometer Controller and the 4 Quadrant Dynamometer Motor are now ready to be used with a specific rotating machine, as mentioned at the beginning of this procedure.

1.9 Function description (Power Supply operating mode)

The 4 Quadrant Power Supply and Dynamometer Controller can perform a wide variety of functions. The standard functions available in the Power Supply operating mode are described in Table 3. Table 4 at the end of this section indicates which of these standard functions are available in each of the two control modes (Manual and Computer-Based).

Function	Description	Figure
Positive Voltage Source	This function uses the four-quadrant power supply to implement a dc voltage source having a positive polarity. The source can either source or sink current (two-quadrant operation). A voltage command entered by the user determines the value of the source voltage. The function indicates the voltage, current, electrical power, and energy at the source output. The function can also indicate circuit temperature (e.g., battery temperature) when a temperature sensor is connected to the <i>Thermistor Input</i> of the 4 Quadrant Power Supply and Dynamometer Controller.	
Negative Voltage Source	Same as the Positive Voltage Source function except for the polarity.	

4 Quadrant Power Supply and Dynamometer Controller

Function	Description	Figure
DC Voltage Source	This function uses the four-quadrant power supply to implement a dc voltage source having either positive or negative polarity. The source can either source or sink current no matter if the source voltage polarity is positive or negative (four-quadrant operation). A voltage command entered by the user determines the polarity and value of the source voltage. The function indicates the voltage, current, electrical power, and energy at the source output. The function can also indicate circuit temperature (e.g., battery temperature) when a temperature sensor is connected to the <i>Thermistor Input</i> of the <i>4 Quadrant Power Supply and Dynamometer Controller</i> .	
Positive Current Source	This function uses the four-quadrant power supply to implement a dc current source that sources current at its output. The polarity of the voltage across the source can be either positive or negative (two-quadrant operation). A current command entered by the user determines the value of the source current. The function indicates the voltage, current, electrical power, and energy at the source output. The function can also indicate circuit temperature (e.g., battery temperature) when a temperature sensor is connected to the <i>Thermistor Input</i> of the <i>4 Quadrant Power Supply and Dynamometer Controller</i> .	
Negative Current Source	Same as the Positive Current Source function except for the direction of current flow.	
DC Current Source	This function uses the four-quadrant power supply to implement a dc current source that either sources current (positive polarity) or sinks current (negative polarity) at its output. The polarity of the voltage across the source can be either positive or negative no matter the direction of the source current (four-quadrant operation). A current command entered by the user determines the direction (polarity) and value of the source current. The function indicates the voltage, current, electrical power, and energy at the source output. The function can also indicate circuit temperature (e.g., battery temperature) when a temperature sensor is connected to the <i>Thermistor Input</i> of the <i>4 Quadrant Power Supply and Dynamometer Controller</i> .	

4 Quadrant Power Supply and Dynamometer Controller

Function	Description	Figure
50 Hz Power Source	This function uses the four-quadrant power supply to implement a non-regulated variable-voltage 50 Hz power source. A voltage command entered by the user determines the rms value of the "no-load" source voltage. The source can either source or sink current no matter if the source voltage polarity (instantaneous) is positive or negative (four-quadrant operation). The function can also indicate the circuit temperature (e.g., transformer core temperature) when a temperature sensor is connected to the <i>Thermistor Input</i> of the 4 Quadrant Power Supply and Dynamometer Controller.	
60 Hz Power Source	Same as the 50 Hz Power Source function except for the frequency.	
AC Power Source	This function uses the four-quadrant power supply to implement a nonregulated variable-voltage, variablefrequency ac power source. The source can either source or sink current no matter if the source voltage polarity (instantaneous) is positive or negative (four-quadrant operation). Voltage and frequency commands entered by the user determine the rms value and frequency of the "no-load" source voltage. The function can also indicate the circuit temperature (e.g., transformer core temperature) when a temperature sensor is connected to the <i>Thermistor Input</i> of the 4 Quadrant Power Supply and Dynamometer Controller.	
200 V DC Bus	This function uses the four-quadrant power supply to implement a fixed-voltage dc bus of 200 V. The dc bus can either source or sink current (two-quadrant operation). The function indicates the voltage, current, electrical power, and energy at the dc bus. The function can also indicate the circuit temperature (e.g., transformer core temperature) when a temperature sensor is connected to the <i>Thermistor Input</i> of the 4 Quadrant Power Supply and Dynamometer Controller.	
Lead-Acid Battery Float Charger	This function uses the four-quadrant power supply to implement a lead-acid battery float charger. This charger applies a constant voltage to the battery. The user only has to specify the battery float charging voltage. The function indicates the voltage, current, electrical power, and energy at the charger output. The Lead-Acid Battery Float Charger function is well suited to charge several lead-acid batteries connected in parallel overnight so they are ready for next-day lab sessions. The function can also indicate circuit temperature (e.g., battery temperature) when a temperature sensor is connected to the <i>Thermistor Input</i> of the 4 Quadrant Power Supply and Dynamometer Controller.	

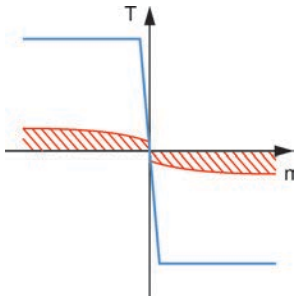
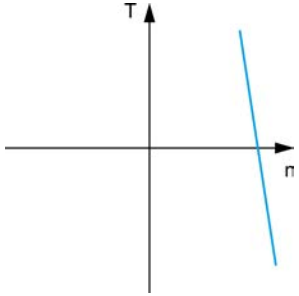
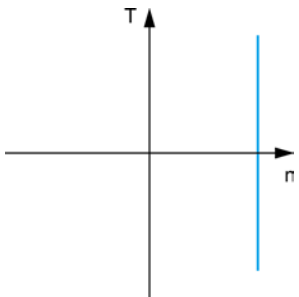
Table 3. Function description (Power Supply operating mode).

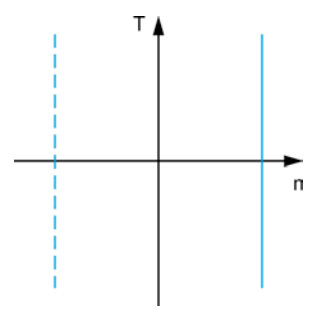
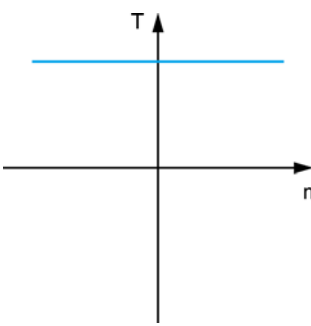
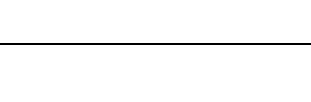
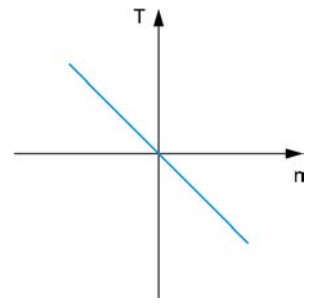
Control functions	Control mode	
	Manual (Stand-Alone)	Computer-Based (LVDAC-EMS)
Positive Voltage Source	•	•
Negative Voltage Source	•	•
DC Voltage Source		•
Positive Current Source	•	•
Negative Current Source	•	•
DC Current Source		•
50 Hz Power Source	•	•
60 Hz Power Source	•	•
AC Power Source		•
200 V DC Bus	•	
Lead-Acid Battery Float Charger	•	•

Table 4. Standard module functions available in each control mode when the [4 Quadrant Power Supply and Dynamometer Controller](#) operates in the Power Supply mode.

1.10 Function description (Dynamometer operating mode)

The [4 Quadrant Power Supply and Dynamometer Controller](#) can perform a wide variety of functions. The standard functions available in the Dynamometer operating mode are described in Table 5. Table 6 at the end of this section indicates which of these standard functions are available in each of the two control modes (Manual and Computer-Based).

Function	Description	Figure
Two-Quadrant, Constant-Torque Brake	<p>This function makes the 4 Quadrant Dynamometer Motor operate as a generator to produce a constant opposition to the rotation of the machine to which it is coupled (i.e., the machine under test). Closed-loop control is used to maintain the opposition torque constant when the rotation speed changes. A torque command entered by the user determines the value (magnitude) of the torque opposing rotation of the machine under test. The function indicates the speed, torque, mechanical power, and energy measured at the shaft of the machine under test. The function can also indicate the machine temperature when the temperature sensor of the machine under test (if so equipped) is connected to the <i>Thermistor Input</i> of the 4 Quadrant Power Supply and Dynamometer Controller.</p>	
Clockwise Prime Mover/Brake	<p>This function uses the 4 Quadrant Dynamometer Motor to make the machine to which it is coupled (i.e., the machine under test) rotate clockwise at a certain speed. The machine speed can be adjusted using the <i>Command</i> knob on the front panel of the module. The function indicates the speed, torque, mechanical power, and energy measured at the shaft of the machine under test. This function is well suited for the study of ac generator synchronization. The function can also indicate the machine temperature when the temperature sensor of the machine under test (if so equipped) is connected to the <i>Thermistor Input</i> of the 4 Quadrant Power Supply and Dynamometer Controller.</p>	
Counterclockwise Prime Mover/Brake	<p>Same as the Clockwise Prime Mover/Brake function except for the direction of rotation.</p>	
Clockwise Constant-Speed Prime Mover/Brake	<p>This function uses the 4 Quadrant Dynamometer Motor to make the machine to which it is coupled (i.e., the machine under test) rotate clockwise at a fixed speed. Closed-loop control is used to maintain the rotation speed constant under varying load conditions. A speed command entered by the user determines the rotation speed of the machine under test. The function indicates the speed, torque, mechanical power, and energy measured at the shaft of the machine under test. The function can also indicate the machine temperature when the temperature sensor of the machine under test (if so equipped) is connected to the <i>Thermistor Input</i> of the 4 Quadrant Power Supply and Dynamometer Controller.</p>	
Counterclockwise Constant-Speed Prime Mover/Brake	<p>Same as the Clockwise Constant-Speed Prime Mover/Brake except for the direction of rotation.</p>	

Function	Description	Figure
<p>Four-Quadrant, Constant-Speed Prime Mover/Brake</p>	<p>This function uses the 4 Quadrant Dynamometer Motor to make the machine to which it is coupled (i.e., the machine under test) rotate at a fixed rotation speed. Closed-loop control is used to maintain the rotation speed constant under varying load conditions. A speed command entered by the user determines the value (direction and magnitude) of the speed at which the machine under test rotates. The function indicates the speed, torque, mechanical power, and energy measured at the shaft of the machine under test. The function can also indicate the machine temperature when the temperature sensor of the machine under test (if so equipped) is connected to the Thermistor Input of the 4 Quadrant Power Supply and Dynamometer Controller.</p>	 <p>A graph with Torque (T) on the vertical axis and speed (n) on the horizontal axis. Two vertical lines are drawn: a dashed blue line on the left side of the graph (negative speed) and a solid blue line on the right side (positive speed). The lines are parallel to the n-axis and intersect the T-axis at the origin.</p>
<p>Positive Constant-Torque Prime Mover/Brake</p>	<p>This function uses the 4 Quadrant Dynamometer Motor to apply a positive (i.e., applied in the clockwise direction) constant torque to the machine to which it is coupled (i.e., the machine under test). Closed-loop control is used to maintain the torque constant as the rotation speed changes, no matter the machine under test operates as a motor or a brake (i.e., a generator). A torque command entered by the user determines the torque applied to the machine under test. The function indicates the speed, torque, mechanical power, and energy measured at the shaft of the machine under test. The function can also indicate the machine temperature when the temperature sensor of the machine under test (if so equipped) is connected to the Thermistor Input of the 4 Quadrant Power Supply and Dynamometer Controller.</p>	 <p>A graph with Torque (T) on the vertical axis and speed (n) on the horizontal axis. A solid blue horizontal line is drawn in the positive torque region, parallel to the n-axis and intersecting the T-axis at a positive value.</p>
<p>Negative Constant-Torque Prime Mover/Brake</p>	<p>Same as the Positive Constant-Torque Prime Mover/Brake except that the torque is negative (i.e., applied in the counterclockwise direction).</p>	 <p>A graph with Torque (T) on the vertical axis and speed (n) on the horizontal axis. A solid blue horizontal line is drawn in the negative torque region, parallel to the n-axis and intersecting the T-axis at a negative value.</p>
<p>Mechanical Load</p>	<p>This function uses the 4 Quadrant Dynamometer Motor to faithfully reproduce the behaviour of various mechanical load found in the industry (i.e., flywheel, fan, conveyor, grinder, calender, crane). A Torque-Speed Characteristic graph is added next to the Meters section to show the current characteristic of the mechanical load selected. The user has control over the Inertia and Friction Torque for each type of load as well as the option to create its own mechanical load by editing the Torque-Speed Characteristic graph at will. The function can also indicate the machine temperature when the temperature sensor of the machine under test (if so equipped) is connected to the Thermistor Input of the 4 Quadrant Power Supply and Dynamometer Controller.</p>	 <p>A graph with Torque (T) on the vertical axis and speed (n) on the horizontal axis. A solid blue diagonal line with a negative slope is drawn, passing through the origin (0,0).</p>

Function	Description	Figure
Speed Sweep	<p>This function uses the 4 Quadrant Dynamometer Motor to make the machine to which it is coupled (i.e., the machine under test) rotate at various speeds within a specific range, in a certain number of steps and in a certain time interval. Closed-loop control is used to ensure accurate speed sweep. The speed sweep performed is defined entirely by the user with only four parameters (start speed, end speed, number of steps, and step duration). The function indicates the speed, torque, mechanical power, and energy measured at the shaft of the machine under test. The function can also indicate the machine temperature when the temperature sensor of the machine under test (if so equipped) is connected to the Thermistor Input of the 4 Quadrant Power Supply and Dynamometer Controller. The Speed Sweep function is useful to measure how parameters related to the machine under test vary as a function of the rotation speed. The parameters measured throughout the speed sweep can be recorded to a data table automatically.</p>	

Table 5. Function description (Dynamometer operating mode).

Control functions	Control mode	
	Manual (Stand-Alone)	Computer-Based (LVDAC-EMS)
Two-Quadrant, Constant-Torque Brake	•	•
Clockwise Prime Mover/Brake	•	•
Counterclockwise Prime Mover/Brake	•	•
Clockwise Constant-Speed Prime Mover/Brake	•	•
Counterclockwise Constant-Speed Prime Mover/Brake	•	•
Positive Constant-Torque Prime Mover/Brake	•	•
Negative Constant-Torque Prime Mover/Brake	•	•
Four-Quadrant, Constant-Speed Prime Mover/Brake		•
Mechanical Load		•
Speed Sweep		•

Table 6. Standard module functions available in each control mode when the [4 Quadrant Power Supply and Dynamometer Controller](#) operates in the Dynamometer mode.

1.11 Specifications

4 Quadrant Power Supply and Dynamometer Controller parameters		Value
Power requirements	Maximum current	3 A
	Electrical installation	230 V-50/60 Hz, must include live, neutral, and ground wires
	Maximum leakage current	1.8 mA
Power Supply mode	DC voltage	0 to ± 150 V
	AC voltage (rms)	0 to 105 V (no-load)
	DC current	0 to ± 5 A
	AC current (rms)	0 to 3.5 A
	Maximum output power	500 W
	AC frequency	10 to 120 Hz
Dynamometer controller	Magnetic torque	0 to 3 N·m
	Direction of rotation	CW/CCW
	Speed	0 to 2500 r/min
	Nominal power	350 W
Liquid Crystal Display (LCD)		76 mm, monochrome, background illuminated, 240 x 160 dots
Control inputs	Command input	0 to ± 10 V
	Thermistor input	10 k Ω , type 1, 2, or 3
Control outputs	Shaft encoder	Quadrature encoder (A-B) - 360 pulses/revolution - TTL compatible
	Torque output sensitivity	0.3 N·m/V
	Speed output sensitivity	250 or 500 r/min/V
Computer I/O interface		USB 2.0 with type B connector
Accessories	2 m USB interconnection cable (1)	
	Detachable power supply cable (1)	
	M3 0.5x12 mm screw (4)	
	Rubber foot for table top usage (4)	
Physical Characteristics	Dimensions (H x W x D)	297 x 266 x 215 mm
	Net weight	10.5 kg

Table 7. 4 Quadrant Power Supply and Dynamometer Controller specifications.

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did@festo.com

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