Data Acquisition and Control Interface

FESTO

Electric Power Technology

User Guide

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Electricity and New Energy

Data Acquisition and Control Interface

User Guide

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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	**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.
CAUTION	**CAUTION** used without the *Caution, risk of danger* 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

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

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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 Data Acquisition and Control Interface

1.1 Introduction to data acquisition and control systems

A data acquisition and control system is a computer-based system that can gather and analyze information from several external sources, and perform different calculations on the acquired data. A single computer can thus replace a variety of meters and instruments, display several waveforms simultaneously, analyze waveforms and data to extract important information, record data, and plot graphs.

Generally, data acquisition and control systems gather information represented by electrical signals. Some information, such as the input or output voltage of an electrical device is already in electrical form. Other information can be converted to electrical form by a transducer. For example, the speed of a motor can be converted into an electrical signal by a speed sensor.

The electrical signal from a speed sensor is called an analog signal because it is analogous to the speed; if the speed increases, the voltage increases, and vice versa. The voltage of an analog signal can vary continuously and take on any value within a certain range.

Computers are digital devices that use discrete numbers to store and process data. A data acquisition and control system, therefore, requires a circuit that converts continuous analog signals to discrete digital values. The type of circuit used for this purpose is called an analog-to-digital converter, or A/D converter. The sampling and conversion process is illustrated in Figure 1.

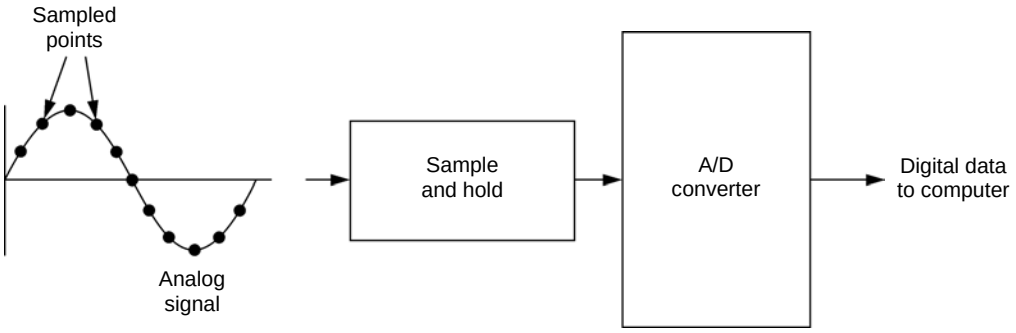

Figure 1. Sampling and analog-to-digital (A/D) conversion of an analog signal.

The analog signal is first sampled at regular intervals by a sample-and-hold circuit, which holds each sampled level until the analog-to-digital (A/D) converter has converted it to a digital number. The rate at which the signal is sampled is called the sampling rate. The higher the sampling rate, the more faithfully the digital numbers produced will follow the original signal. High sampling rates, however, generate lots of numbers and these may fill the computer memory very quickly, so the sampling rate should not be too high.

When a data acquisition and control system must acquire data from several different sources, a single A/D converter can be used along with a multiplexer, as shown in Figure 2. The multiplexer is a switch that selects each analog input, or channel, in turn. Each time the multiplexer selects a new analog input, the signal present at the input is sampled and converted to a digital number.

The number of channels sampled by the multiplexer affects the sampling rate per channel. If the A/D converter can convert 100 000 samples per second, a single channel could be sampled at that rate.

However, if two channels were used, each channel would be sampled at 50 000 samples per second, and four channels would be sampled at 25 000 samples per second.

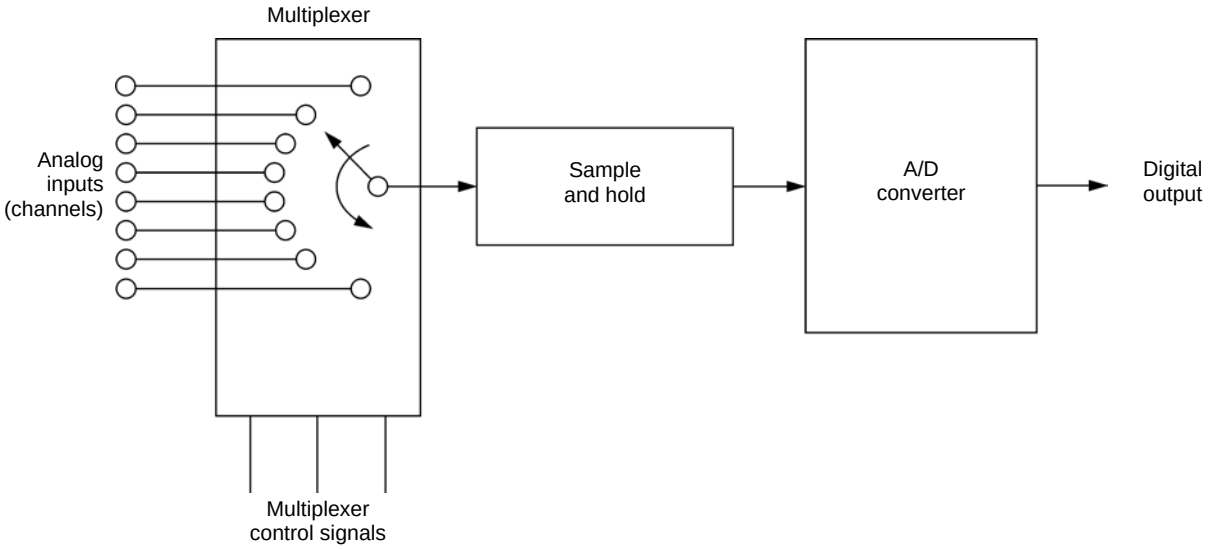

Figure 2. Input configuration of a typical multi-channel A/D converter.

Depending on the application, a data acquisition and control system may sample signals continuously, or it may take a certain number of samples and then stop sampling until commanded to take another batch of samples. In either case, the digital numbers representing the samples can be processed and analyzed by the computer to extract useful information. Usually, this information can be presented on the computer screen in different ways, which are selected by the user of the system.

1.2 Description of the Data Acquisition and Control Interface (DACI)

The Data Acquisition and Control Interface (DACI) is a versatile USB peripheral used for measuring, observing, analyzing, and controlling electrical and mechanical parameters in electric power systems and power electronics circuits. The DACI is intended to be used with the LVDAC-EMS software. Together, the DACI and the LVDAC-EMS software provide a complete set of computer-based instruments, as well as a variety of control functions. The provided instruments include voltmeters, ammeters, power meters, frequency meters, efficiency meters, impedance meters power factor meters, energy meters, torque and speed meters, an oscilloscope, a phasor analyzer, a harmonic analyzer, and a synchroscope. The DACI and LVDAC-EMS also allow manual and timed data recording. The recorded data can be saved to files in any specified location, graphically represented with the provided graph plotting tool, and exported into a spreadsheet application. LVDAC-EMS also offers the possibility to use pre-built SCADA interfaces for several applications to ease the view and understanding of the process taking place.

> The LVDAC-EMS software, as well as all available upgrades, is free and can be downloaded anytime on the Festo Didactic website.

The DACI and LVDAC-EMS can also be used with the 4 Quadrant Power Supply and Dynamometer Controller to implement a variety of control functions for advanced training in various fields of electricity and new energy,including electric power technology, ac/dc rotating machines, renewable energy, transmission lines, and power electronics.

The DACI has two main functions: it performs data acquisition to feed raw signal data to the LVDAC-EMS computer-based instruments, and it performs various types of control functions, mainly to control electronic switches in some training modules. The DACI can perform these two functions at the same time. However, when a complex control function is implemented, certain voltage inputs (U) or current inputs (I) of the DACI are not available for the computer-based instrumentation.

To activate data acquisition for a specific computer-based instrumentation function, a license for this function must be ordered for each DACI on which the function is to be used. Similarly, to activate a specific control function, a license for this function must be ordered for each DACI on which the function is to be used.

The firmware (the program used to run the microcontroller) of the DACI can be upgraded anytime by using the device firmware upgrade (DFU) included with the latest version of LVDAC-EMS available on the Festo Didactic website.

Refer to the user guide entitled "Computer-Based Instruments for EMS" to learn how to install and run the LVDAC-EMS software for use with the DACI and to become familiar with the following computer-based instruments: Metering window, Oscilloscope, Phasor Analyzer, and Harmonic Analyzer.

1.3 DACI operation

The DACI consists of an insulation unit, a data acquisition, and a control unit.

- The insulation unit insulates and converts the high-level voltages and currents applied to the voltage and current inputs of the DACI into low-voltage signals. Each low-voltage signal is proportional to, and electrically insulated from, the high-level electrical signal present at the corresponding input. The low-voltage signals and other signals coming from low-voltage inputs of the DACI are internally routed to the data acquisition and control unit.
- The data acquisition and control unit contains the circuitry needed for analog signal sampling and A/D conversion. It converts the low-voltage signals into corresponding digital data. The digital data is then read and analyzed by the LVDAC-EMS software. The results are displayed on the computer screen according to the representation selected by the user. The display can be a panel of meters showing the values of the measured parameters, an oscilloscope showing the waveforms of the measured parameters, etc.

A high-speed USB port cable is used to connect the DACI module to the personal computer. Figure 3 gives an overview of the data acquisition and control process.

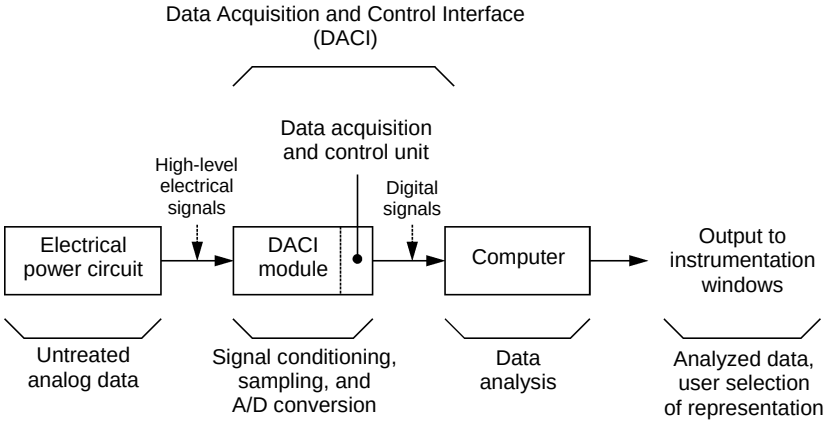

Figure 3. Overview of the data acquisition and control process in the LVDAC-EMS system.

1.4 DACI model variants

The DACI is available in several model variants. Each variant has a unique combination of functions pre-activated at the factory. At any time, an additional function can be activated in a DACI by purchasing a license for that specific function and then performing the upgrade procedure on the DACI. The following functions are available:

- Computer-Based Instrumentation Function
- Chopper/Inverter Control Function Set
- Thyristor Control Function Set
- Home Energy Production Function set
- Three-Phase PWM Rectifier/Inverter Control Function Set
- BLDC Motor/PMSM Control Function Set
- High-Voltage DC (HVDC) Transmission System Control Function Set
- Static Var Compensator (SVC) Control Function Set
- 9063 SDK (Software Development Kit)
- Synchronous Generator Control Function Set
- Static Synchronous Compensator (STATCOM) Control Function Set
- Synchroscope Function

1.5 Setup procedure for DACI operation with the LVDAC-EMS software

Before performing the manipulations below, make sure that you have the latest version of LVDAC-EMS on your computer. It is available on the Festo Didactic website. You can verify that you have the latest software version by selecting *Check for Update* in the *Help* menu of the software.

1. Install the DACI and the AC 24V Power Supply in the workstation.
2. 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.

3. Make sure that the main power switch of the AC 24V Power Supply is set to the *O* (off) position. Then, connect the *Power Input* of the AC 24V Power Supply 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 make sure that the ac power outlets to which you connect the equipment are properly protected.

4. Turn on (i.e., unlock) electric power at your workstation.

If necessary, ask the assistance of your supervisor.

5. Connect the *Power Input* of the DACI to the *Power Output* of the AC 24V Power Supply module.

   Turn the AC 24V Power Supply on. Notice that the *Power Input* LED on the Data Acquisition and Control Interface lights up to indicate that power is supplied to the module.

6. Connect the USB port of the DACI to a USB port of the host computer.
7. Turn the host computer on and then start the LVDAC-EMS software.

   In the LVDAC-EMS Start-Up window, make sure that the Data Acquisition and Control Interface is detected. Make sure that the *Computer-Based Instrumentation* function for the Data Acquisition and Control Interface is 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 appear on the screen indicating that the firmware in the DACI needs an update before proceeding. In that case, follow the instructions on the screen to update the firmware of the DACI.

Complete instructions on how to use control applications of the DACI are available in the Student Manual(s) going with the related courseware only.

1.5.1 Function set activation procedure

When you buy a new function set for the DACI, you must activate this new function set by performing the procedure below.

1. Perform the *Setup procedure for DACI operation with the LVDAC-EMS software* described above.
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 required 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 DACI 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 DACI.

4. Follow the on-screen instructions to activate the new function set(s) in the DACI.

You will have to restart the LVDAC-EMS software for the new function set(s) to become available.

1.6 Specifications

DACI module parameters		Value
Power requirements	Voltage	24 V
	Maximum current	0.4 A
	Frequency	50/60 Hz
Insulated voltage inputs (4)	Range (low/high scales)	-80 to +80 V/-800 to +800 V (user-selectable through software)
	Impedance (low/high scales)	326.6 kΩ/3.25 MΩ
	Bandwidth	DC to 65 kHz (-3dB)
	Accuracy	1% (dc to 10 kHz)
	Insulation	400 V versus earth
	Measurement category	CAT II (283 V ac/400 V dc versus earth)
Insulated current inputs (4)	Range (low/high scales)	-4 to +4 A/-25 to +25 A (40 A peak)
	Impedance (low/high scales)	50 mΩ/5 mΩ
	Bandwidth	DC to 65 kHz (-3 dB)
	Accuracy	1% (dc to 10 kHz)
	Insulation	400 V versus earth
	Measurement category	CAT II (283 V ac/400 V dc versus earth)
Analog inputs (8)	Voltage range	-10 to +10 V
	Impedance	› 10 MΩ
	Bandwidth	DC to 125 kHz
	Measured parameters	User-selectable through software
	Parameter-to-voltage ratio	User-determined through software
A/D converter for insulated and analog inputs (16)	Type	Successive approximation
	Resolution	12 bits
	Integral non-linearity	≤ ± 1.5 LSB
	Differential non-linearity	≤ ± 1 LSB
	Maximum sampling rate	600 ksamples/s (one channel)
	FIFO buffer size	16 ksamples
Analog outputs (2)	Voltage range	-10 to +10 V
	Operational load impedance	› 600 Ω

DACI module parameters		Value
D/A converter for analog outputs (2)	Type	Resistor string
	Resolution	12 bits
	Integral non-linearity	≤ ± 8 LSB
	Differential non-linearity	-0.5 to +0.7 LSB
Digital inputs (3)	Types	Encoder (2), synchronization (1)
	Signal level	0 - 5 V (TTL compatible)
	Maximum input frequency	50 kHz
	Impedance	5 kΩ
Digital outputs (9)	Types	Control (6 on a DB9 connector and 2 on 2 mm banana jacks), synchronization (1 on a DB9 connector)
	Signal level	0-5 V (TTL compatible)
	Maximum output frequency	20 kHz (software limited)
	Impedance	200 Ω
Computer I/O interface		USB 2.0 port with type B connector
Accessories		2 m USB interconnection cable (1)
		24 V power cable (1)
Personal computer requirements		A personal computer with a USB port, running under one of the following Microsoft® operating systems, Windows®7, Windows®8, or Windows®10, is required.
Physical characteristics	Dimensions (H x W x D)	297 x 266 x 140 mm
	Net weight	4.6 kg

Table 1. Specifications of the Data Acquisition and Control Interface.

Parameters of the computer-based instrumentation functions of the DACI		Values
Metering	Number of meters	18
	Sampling window	320 ms or user adjusted through software (11.4 to 819 ms)
	Sampling frequency (each meter)	6.4 kHz or user adjustable with software (2.5 to 179.2 kHz)
	Display type	Digital or analog, user selectable with software
Oscilloscope	Number of channels	8
	Vertical sensitivity	2 to 500 V/div.
	Time base	0.1 ms/div. to 10 s/div.
	Sampling window	20 x selected time base (software triggering)/ 10 x selected time base (hardware triggering)
	Sampling frequency	512 samples per measured parameter per horizontal sweep,up to a maximum of 512 kHz
Phasor Analyzer	Sensitivity	2 to 200 V/div., 0.1 to 5 A/div.

Parameters of the computer-based instrumentation functions of the DACI		Values
	Sampling window	Software adjusted (2 to 409 ms)
	Sampling frequency (each phasor)	Software adjusted (5 to 102.4 kHz)
Harmonic Analyzer	Fundamental-frequency range	1 to 1400 Hz
	Number of harmonic components	5 to 40, user selectable with software
	Vertical scale (relative scale)	0.1 to 10%/div.
	Vertical scale (absolute scale)	0.1 to 50 V/div., 0.01 to 10 A/div.
	Sampling window	Software adjusted (10 ms to 1 s)
	Sampling frequency	Software adjusted (16 to 102 kHz)
Synchroscope	Values monitored	Network voltage, generator voltage, voltage difference, network frequency, generator frequency

Table 2. Specifications of the computer-based instrumentation functions of the Data Acquisition and Control Interface (DACI).

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