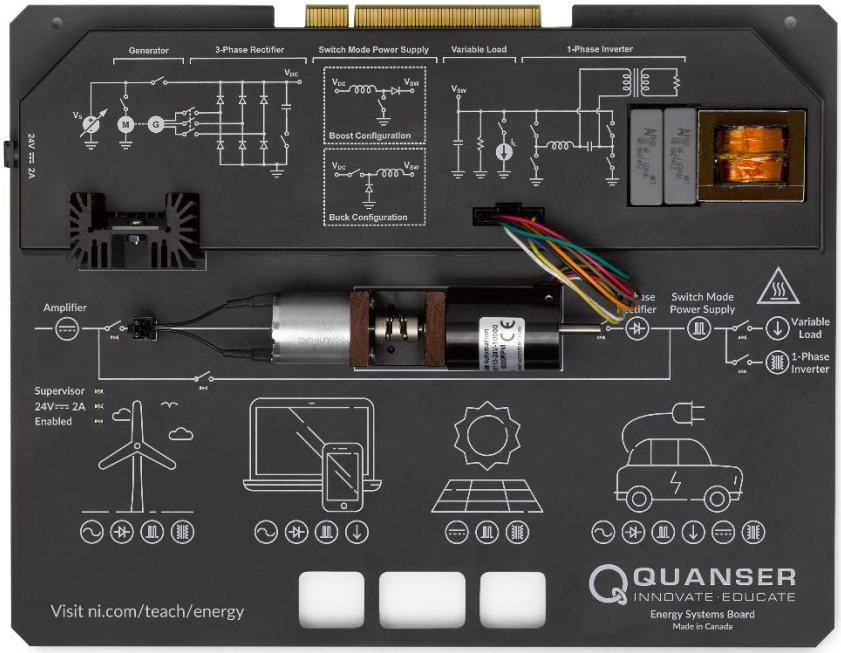
User Manual

Quanser Energy Systems Board for NI ELVIS III



Setup and Configuration

Printed in Markham, Ontario.

Safety Information

The following symbols and definitions are interchangeably used throughout the User Manual:

Symbol	Description
	Caution: consult documentation for additional information
	Attention: Observe precautions for handling electrostatic sensitive devices

The Quanser Energy Systems Board

The Quanser Energy Systems board, pictured in Figure 1, is a versatile system designed to allow students to investigate and explore various sub-components of an electromechanical power system. Topic range from AC power generation, rectification and inversion to buck and boost DC power conversion. The system consists of a DC power source and three phase AC generator, three phase rectifier, switched mode power supply, inverter and transformer, DC current sink, and modifiable LabVIEW controllers. The board can be easily adapted to a wide range of energy system applications such as wind and solar power generation as well as consumer power supplies and electric vehicles.

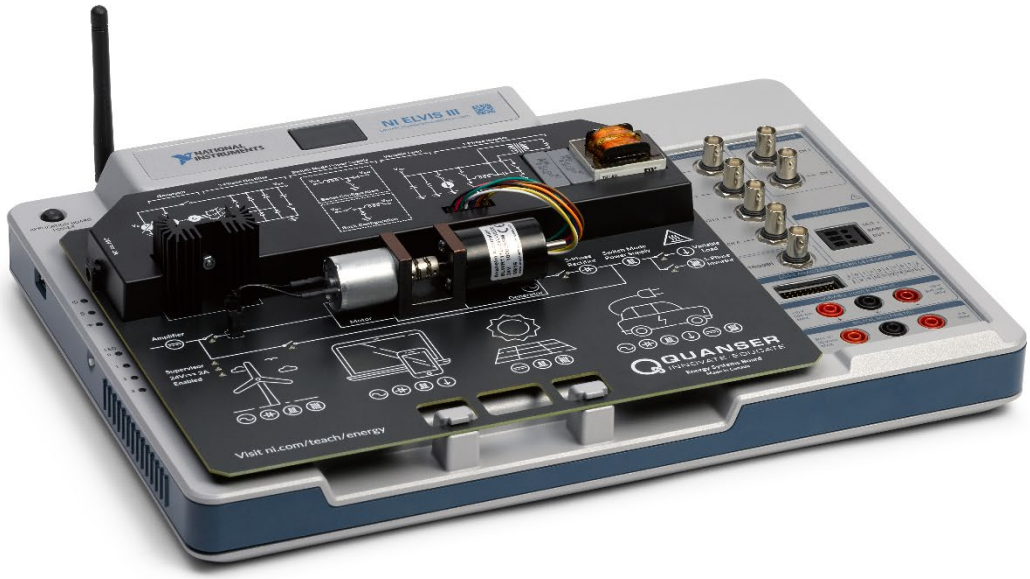


Figure 1: The Quanser Energy Systems board

Main Features

- Variable linear DC power supply
- Three-phase AC generator assembly
- Three-phase rectifier with selectable capacitance
- Buck and boost switched-mode DC power supply circuits
- Single phase inverter circuit with transformer and resistive AC load
- Adjustable DC current sink

Caution

This equipment is designed to be used for educational and research purposes and is not intended for use by the general public. The user is responsible to ensure that the equipment will be used by technically qualified personnel only.

System Schematic

Control of the Energy Systems hardware is achieved by means of an onboard supervisor which prevents the system from being configured in a manner which would damage the board. The PC communicates with the NI ELVIS III via network or USB. The NI ELVIS III sends configuration commands to the supervisor which returns any error state data. Further information about the system state, such as sensed voltages and other sensor data is provided directly to the analog and digital inputs on the NI ELVIS III.

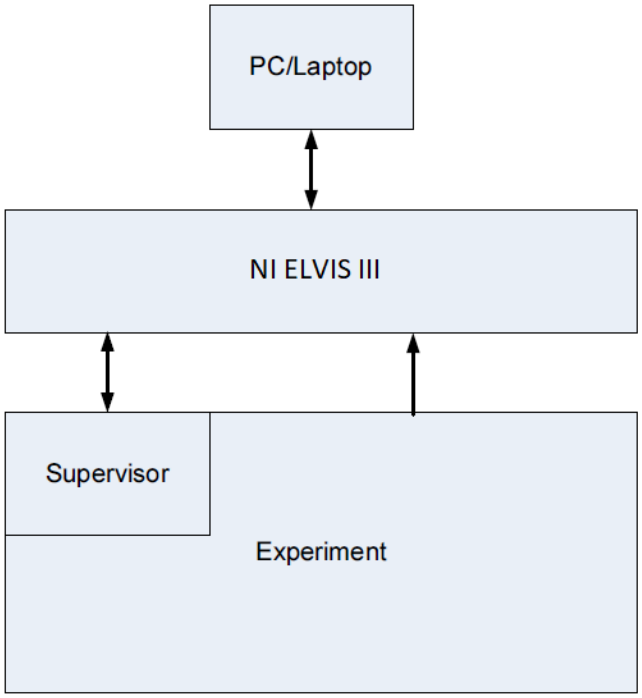


Figure 2: Interaction between components of the board and the NI ELVIS III

Hardware Components

The major components of the application board are identified in Figure 3.

Table 1: Application board hardware components

ID	Component	ID	Component
1	PCI Connector for interfacing with NI ELVIS III	5	Variable DC source
2	24 volt DC power source connector	6	Brushed DC motor (used to drive AC generator assembly)
3	AC transformer and inverter capacitors	7	Three-phase AC generator (BLDC)
4	Rectifier, SMPS, inverter and current sink circuitry (under cover)	8	Status indicator LEDs

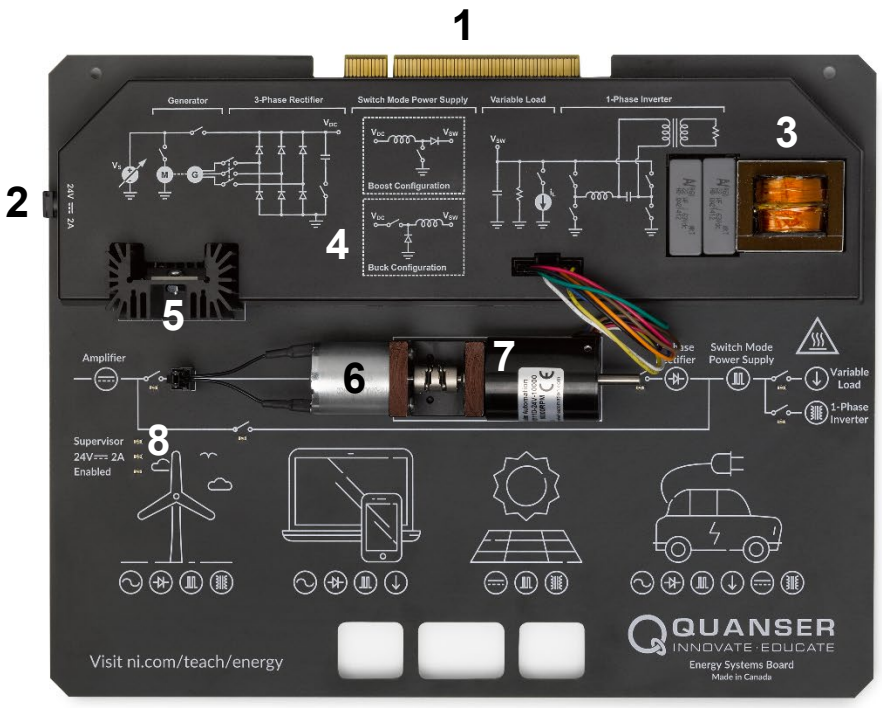


Figure 3: Quanser mechatronic systems board components

Caution Exposed moving parts.

DC Source Linear Amplifier

The Energy Systems board uses a power op amp to supply either the DC motor or the SMPS, depending on the mode of operation. It has a voltage compliance of 0 to 21V.

Three-phase AC Generator and Rectifier

The Energy Systems board uses the Anaheim Automation BLWR11D-24V-10000 brushless DC Motor as a three-phase AC Generator. The complete specification sheet of the BLDC is available from Anaheim Automation.

The rectifier can be dynamically configured for 3-phase or single phase operation with or without bulk capacitors of 1 and/or 10 µF.

Generator Drive Motor

The Energy Systems board uses a brushed DC motor to drive the AC generator assembly. The included DC motor is a Kinmore Motor RF-370CHV-13455. More information on this motor is available from Kinmore Motors.

Switched Mode Power Supply

The switched mode power supply can be configured as a buck or a boost. A maximum switching frequency of 25 MHz is enforced for both topologies. The boost configuration is limited to a duty cycle range of 0 to 50 % and an on-time of 150 µs. The maximum boost output voltage is 30 volts.

Variable DC Current Sink

The variable current sink on the Energy Systems board is nominally capable of sinking 250 mA, given a source above 7V with a low output impedance. Attempting to command loads in excess of 250 mA will cause the load to saturate near 300 mA.

Single Phase Inverter

The single phase inverter on the Energy Systems board is capable of being driven by a reference voltage from either the real-time processor or FPGA on the NI ELVIS III. The inverter requires an input voltage between 10.5 and 30 VDC in order to be enabled. Once enabled, the inverter will cause an error state if the source voltage drops below 8.5 VDC.

Environmental

The application board is designed to function under the following environmental conditions:

- Standard rating
- Indoor use only
- Temperature 5◦C to 40◦C
- Altitude up to 2000 m
- Maximum relative humidity of 80% up to 31◦C decreasing linearly to 50% relative humidity at 40◦C
- Pollution Degree 2
- Maximum transient overvoltage 2500 V
- Marked degree of protection to IEC 60529: Ordinary Equipment (IPX0)

System Setup

The procedure to set up the application board on the NI ELVIS III module is detailed in this section.

Caution

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

ESD Warning

The electrical components on the Quanser Energy Systems board are sensitive to electrostatic discharge (ESD). Before handling the board ensure that you have been properly grounded.

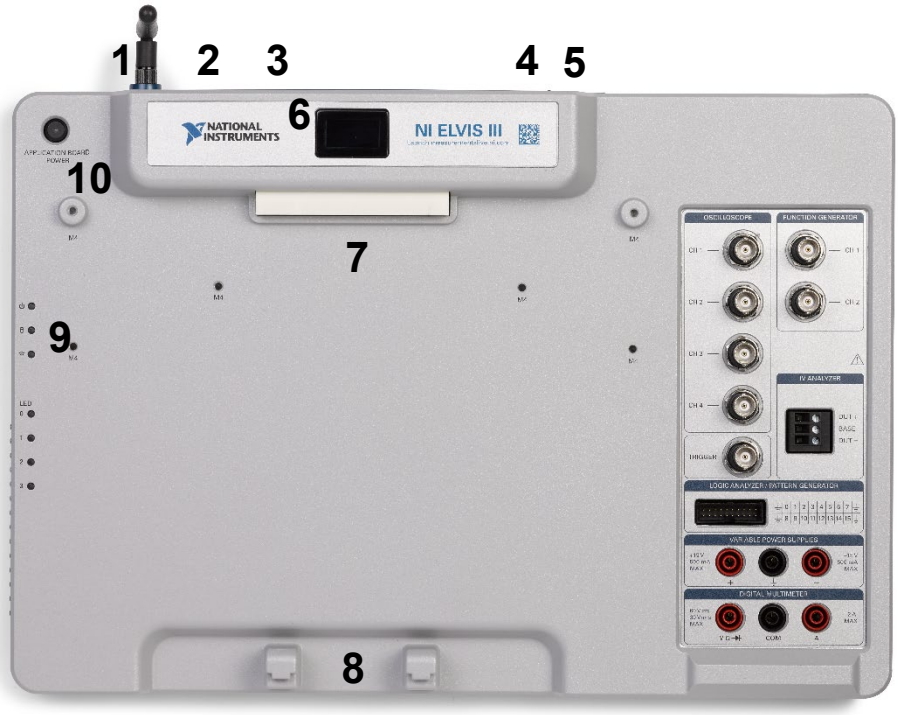


Figure 3: Components of the NI ELVIS III

Table 2: NI ELVIS III Hardware Components

ID	Component	ID	Component
1	Antenna connector	6	Connection data screen
2	Ethernet connector	7	PCI connector
3	USB C connector	8	Handle latching hooks
4	Power cable	9	Status LEDs
5	Power switch	10	Application board power button

Caution Do NOT make the following connections while power is supplied to the application board!

Caution The unit is provided with a grounded cord to be used with a properly grounded outlet only, this is a safety feature, do not disable it.

Follow these instructions to setup the application board on the NI ELVIS III:

1. Power on the ELVIS III
2. Connect the ELVIS III to the network or to your computer via USB C
3. Ensure the LED on the application board power button is NOT lit
4. Position the handle of the application board over the handle latching hooks
5. Position the PCI connector on the application board so that it aligns with the PCI connector on the ELVIS III
6. Push the application board upward until the PCI connector is firmly seated
7. Connect the provided 24 V external power supply to the 24 volt DC power source connector
8. Ensure that the 24V⎓2A indicator LED is lit
9. Press the application board power button and ensure the LED on the button is lit

Troubleshooting

Please review the following before contacting technical support.

1. Verify the board is properly seated on the ELVIS III and that it has power.
2. Verify that the ELVIS III is correctly set up as outlined in the NI product documentation.

You are getting 'VI Missing' messages

Make sure the required LabVIEW add-ons listed in the Quick-Start Guide are installed. Verify that the correct LabVIEW version is installed (The ELVIS III is only compatible with LabVIEW 2018 or later).

Board does not respond

Check that the supervisor error status is “None”. If there is a supervisor error code, consult Table 3 for details on the error.

Table 3: Supervisor error codes

Code	Name	Details
0x0000	None	No errors detected
0x0001	Power not good	External 24 V power supply outside acceptable voltage (or not present)

0x0002	Watchdog expired	A watchdog must be cleared ever 25 ms. Failure to do so indicates loss of communication with the NI ELVIS III.
0x0004	Boost over-voltage	Voltage at the output of the SMPS exceeds 30 V
0x0008	Boost on-time limit	Boost switch on-time exceeded 150 µs (boost switching frequency too low, or duty cycle too high)
0x0010	Boost max duty cycle	Boost PWM duty cycle exceeded 50%
0x0020	Inverter under-voltage	Inverter supply voltage dipped below 8.5 V while the inverter was enabled
0x0040	DC motor stall	DC motor was driven at >14 V and no rotation was detected via hall sensors
0x0080	Buck under-voltage	Buck circuit supply voltage dipped below 5.5 V while the buck converter was active
0x0100	SMPS maximum frequency	SMPS PWM frequency exceeded 25 kHz
0x0200	Source over-temperature	DC power source amplifier temperature sensor exceeds 45 degrees Celsius
0x0400	Sink over-temperature	DC current sink temperature sensor exceeds 70 degrees Celsius

Motors are not responding

Ensure that both the 2-pin connector for the brushed DC motor and the 8-pin connector on the AC generator are connected. Ensure that the motor assembly spins freely.