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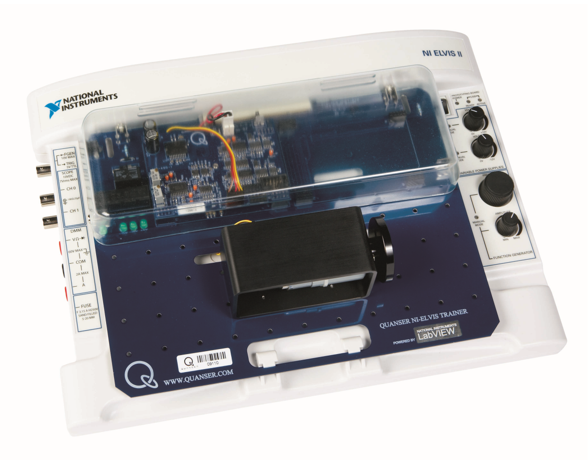

QNET DC Motor Control

User Manual

QNET DCMCT

Quanser Inc.
2011

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1 INTRODUCTION

The DC Motor Control Trainer (DCMCT) is a versatile unit designed to teach and demonstrate the fundamentals of motor servo control in a variety of ways. The system can readily be configured to control motor position and speed. In particular, the system can be used to teach PID control fundamentals. This is done using a PC with real-time control capabilities and either the NI ELVIS I and the NI ELVIS II. The hardware of the DCMCT is described in Section 2. A schematic of the hardware components is included in Section 3, and the specifications are listed in Section 4 and Section 5. Some helpful LabVIEW hints when using the QNET VIs are given in Section 7 along with a troubleshooting guide in Section 8.

Figure 1.1: QNET DC motor control trainer (DCMCT)

2 SYSTEM DESCRIPTION

2.1 DCMCT COMPONENTS

The components comprising the DC Motor Trainer are labeled in Figure 2.2, and Figure 2.3. and are described in Table 1.

ID#	Description	ID#	Description
1	DC Motor	6	QNET PWM/Encoder board
2	High-resolution encoder	7	24V QNET power jack
3	Motor metal chamber	8	Fuse
4	Inertial load	9	+B, +15V, -15V, +5V LEDs
5	PCI connector to NI ELVIS: for interfacing QNET module with DAC		

Table 1: DCMCT component nomenclature

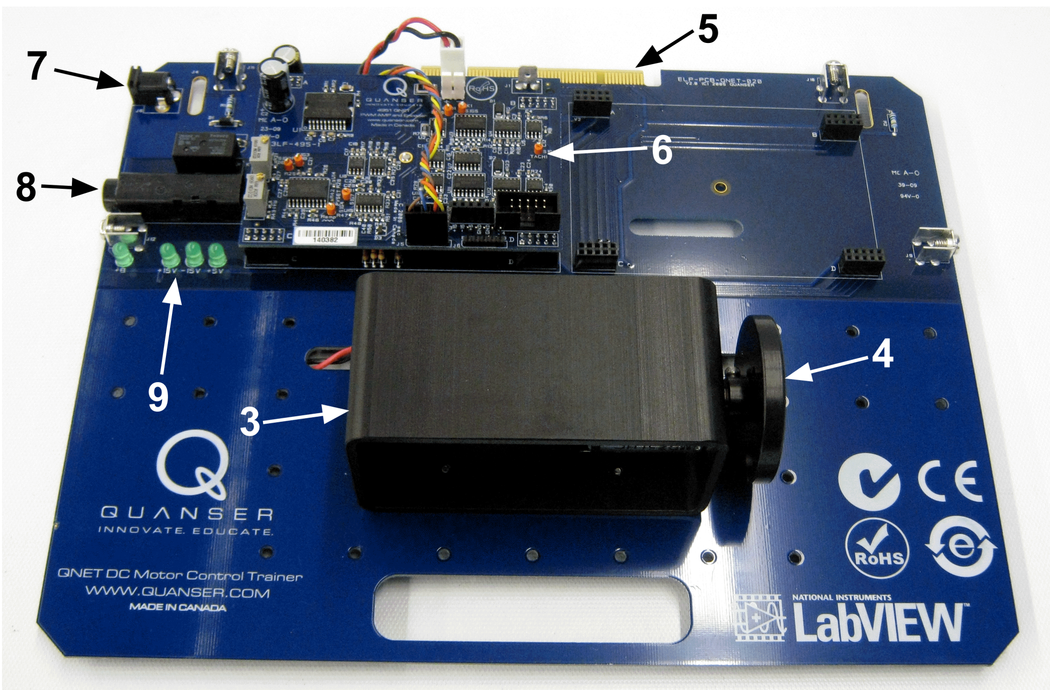

Figure 2.2: General layout of QNET DCMCT

2.1.1 DC Motor

The 12-Volt DC motor has 5 commutator segments, 64 windings per pole, and has a flux ring. The Coulomb friction of the motor corresponds to a voltage between 0.5 and 1.5 V.

2.1.2 Pulse-Width Modulated Power Amplifier

A PWM power amplifier is used to drive the motor. The input to the amplifier is the output of the Digital-to-Analog converter (i.e. D/A) of channel #0 on the DAQ. The maximum output voltage of the amplifier is 24 V. Its maximum peak current is 5 A and the maximum continuous current is 4 A. The amplifier gain is 2.3 V/V.

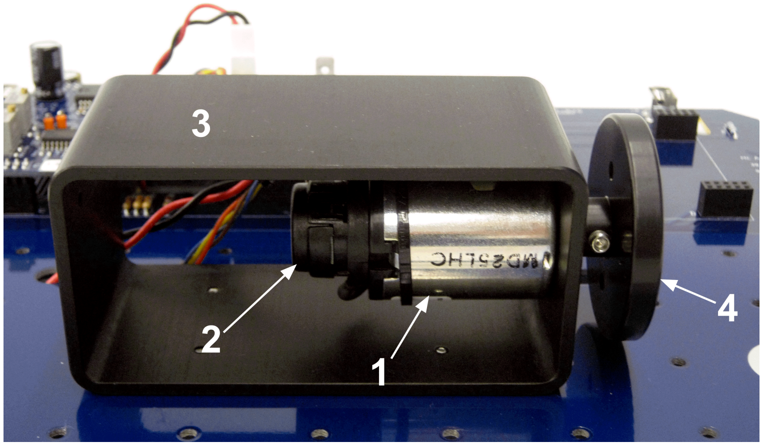

Figure 2.3: QNET DC motor components

2.1.3 Analog Current Measurement: Current Sense Resistor

A series load resistor of 0.1 Ω is connected to the output of the PWM amplifier. The signal is amplified internally to result in a sensitivity of 1.0 V/A. The obtained current measurement signal is available at the Analog-to-Digital (i.e. A/D) of channel #0. Such a current measurement can be used to monitor the current running in the motor.

2.1.4 Digital Position Measurement: Optical Encoder

Digital position measurement is obtained by using a high-resolution quadrature optical encoder. This optical encoder is directly mounted to the rear of the motor. The encoder count measurement is available at Digital Input (i.e. DI) channel #0 of the DAQ.

2.1.5 Analog Speed Measurement: Tachometer

An analog signal proportional to motor speed is available at the Analog-to-Digital (i.e. A/D) Input channel #4 on the DAQ. It is digitally derived from the encoder signal on the QNET DCMCT board.

2.1.6 Fuse

The QNET power amplifier has a 250 V, 3 A fuse.

2.1.7 QNET Power Supply

The DCMCT module has a 24-Volt DC power jack to power the on-board PWM amplifier. It is called the QNET power supply. The +B LED on the QNET board turns bright green when the amplifier is powered.

■ **Caution:** Please make sure you use the correct type of wall transformer or you will damage the system. It should supply 24 VDC and be rated at 3.0 A.

3 SYSTEM SCHEMATIC

A schematic of the DCMCT system interfaced with a DAQ device is provided in Figure 3.4.

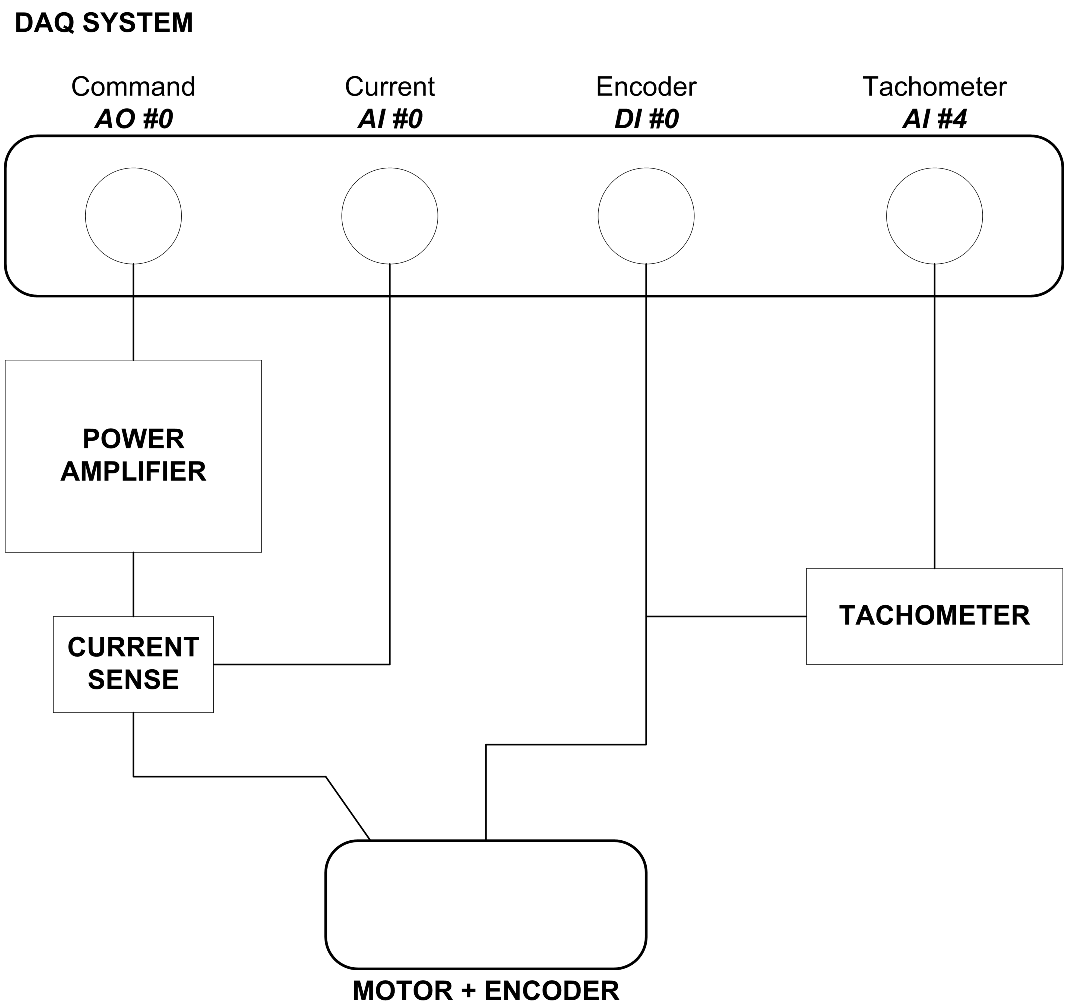

Figure 3.4: Schematic of QNET-DCMCT system

4 SPECIFICATIONS

The specifications of the DCMCT system model parameters are given in Table 2.

Symbol	Description	Value	Unit
	Motor:		
R_m	Motor armature resistance	8.7	Ω
K_t	Motor current-torque constant	0.03334	N·m
K_m	Motor back-emf constant (same as K_t in SI units)	0.03334	V/(rad/s)
J_m	Moment of intertia of motor rotor	1.80×10^{-6}	kg·m^2
	Maximum continuous torque	0.10	N·m
	Maximum power rating	20.0	W
	Maximum continuous current	1.0	A
M_l	Inertial load disk mass	0.033	kg
r_l	Inertial load disk radius	0.0242	m
	Pulse-Width Modulated Amplifier:		
V_{MAX}	PWM amplifier maximum output voltage	24	V
	PWM amplifier maximum output current	5	A
	PWM amplifier gain	2.3	V/V

Table 2: DCMCT model parameter and PWM power amplifier specifications

The specifications on the DCMCT system sensors are given in Table 3.

Description	Value	Unit
Current Sense:		
Current Calibration	1.0	A/V
Current sense resistor	0.1	Ω
Motor Encoder:		
Encoder line count	360	lines/rev
Encoder resolution (in quadrature mode)	0.25	deg/count
Encoder type	TTL	
Encoder signals	A,B	
Tachometer:		
Tachometer calibration at QNET A/D input	2987	RPM/V

Table 3: DCMCT sensor parameter specifications

5 ENVIRONMENTAL

The DC motor control trainer environmental operating conditions are given in Table 4.

Description	Value	Unit
Operating temperature	15 to 35	°C
Humidity	20 to 90	%

Table 4: QNET DC motor control trainer environmental operating conditions

■ **Caution:** Ensure the unit is operated under the temperature and humidity conditions given in Table 4. Otherwise, there may be some issues with the motion control results.

6 SETUP GUIDE

As illustrated in Figure 6.5, the QNET boards can easily be connected to an NI ELVIS system. The instructions in Section 6.1 detail the setup procedure for using a QNET with an NI ELVIS II. For the setup procedure when using the NI ELVIS I platform, please refer to Section 6.2.

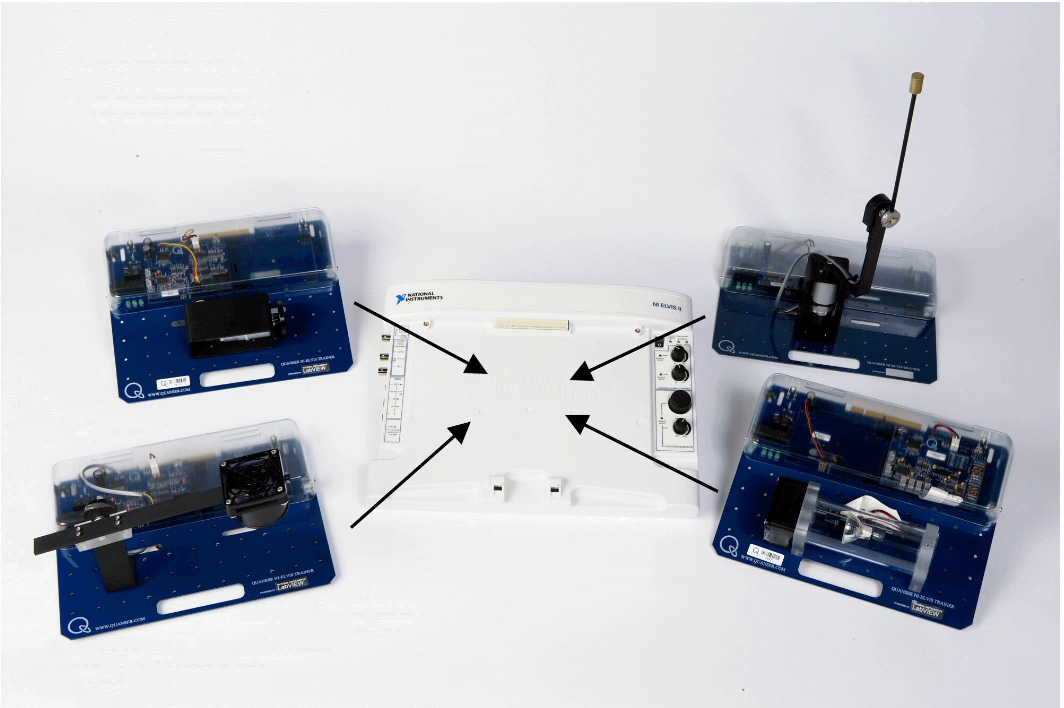

Figure 6.5: Connecting a QNET Trainer

■ **Caution: Do not position the ELVIS II so that it is difficult to disconnect the main power.**

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

6.1 QNET AND NI ELVIS II SETUP

The procedure to install a Quanser Engineering Trainer (QNET) module on the NI ELVIS II is detailed in this section. An example of an installed system using the QNET DC Motor Control Trainer (DCMCT) module is pictured in Figure 6.6. Some of the components used in the installation procedure are located and marked by an ID number in Figure 6.6, and described in Table 5.

6.1.1 ELVIS II Components

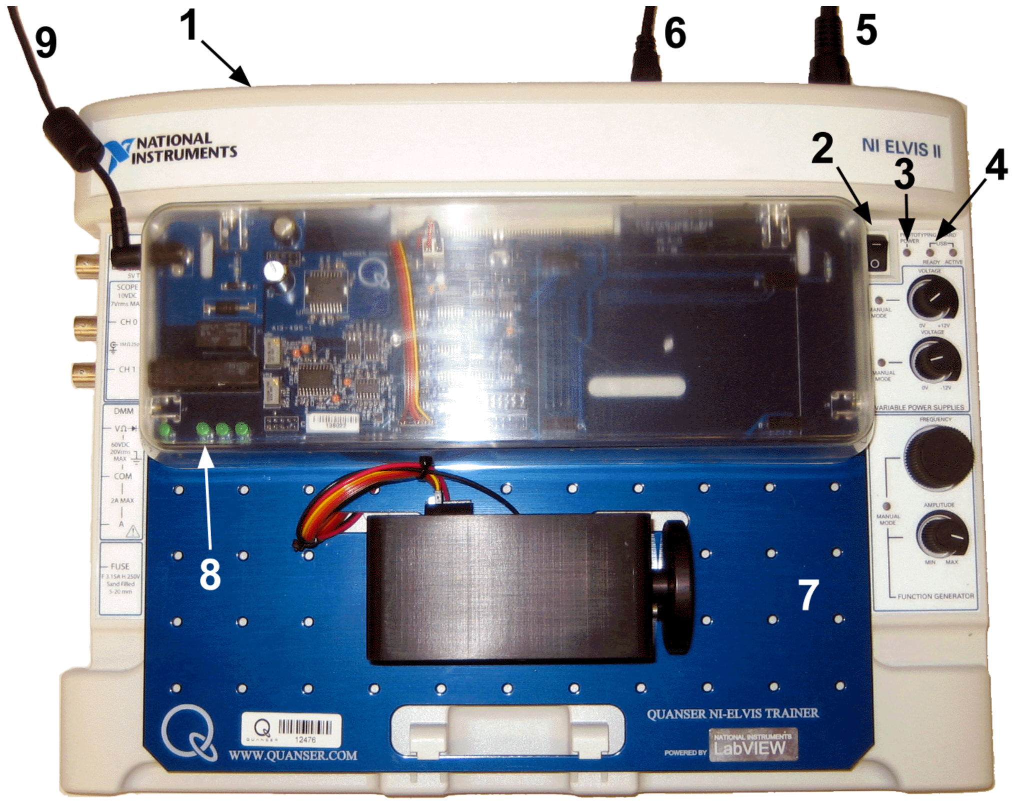

Figure 6.6: Components on ELVIS II and QNET

ID#	Description	ID#	Description
1	NI ELVIS II	6	USB Connection between PC and ELVIS II
2	Prototyping board power switch	7	QNET DCMCT
3	Power LED	8	QNET Power LEDs
4	Ready LED	9	QNET Power Cable
5	Power Cable for ELVIS II		

Table 5: ELVIS II and QNET components

6.1.2 ELVIS II Setup Procedure

Follow these instructions to setup a QNET board on an ELVIS II:

■ **Caution: Do NOT make the following connections while power is supplied to the hardware!**

1. Place the small opening on the front of the QNET board over the mounting bracket on the NI ELVIS II.
2. Slide the PCI connector of the QNET module end into the female connector on the NI ELVIS II. Make sure it is connected properly.
3. Connect the ELVIS II power cable.
4. Connect the ELVIS II USB cable to the PC.
5. Connect the supplied QNET transformer to the QNET power jack on the QNET module.

   Note: Not required for the QNET mechatronic sensors trainer.
6. Power the NI ELVIS II by turning ON the *System Power Switch* on the rear panel.
7. Turn ON the *Prototyping Board Power* switch, ID #2 shown in Figure 6.6.

   ■ **Caution: Turn OFF the *Prototyping Board Power* switch if**

   - On the QNET-DCMCT, QNET-ROTPENT, or QNET-VTOL Trainer the DC motor begins to turn
   - On the QNET-HVACT the halogen light turns on brightly

   Take extra care when powering the QNET module to avoid causing any damage!
8. The *Power* and *Ready* LEDs of the NI ELVIS II unit should be lit as shown in Figure 6.7.

Figure 6.7: Ready and Power LEDs on NI ELVIS II

9. As pictured in Figure 6.8, verify that the *+15V*, *-15V*, *+5V*, and *+B* LEDs on the QNET module are lit. They indicate that the board has been properly connected to the ELVIS unit.

   Note: For the QNET-MECHKIT, ensure the *+15V*, *-15V*, and *+5V* LEDs are lit (it does not require QNET power supply).

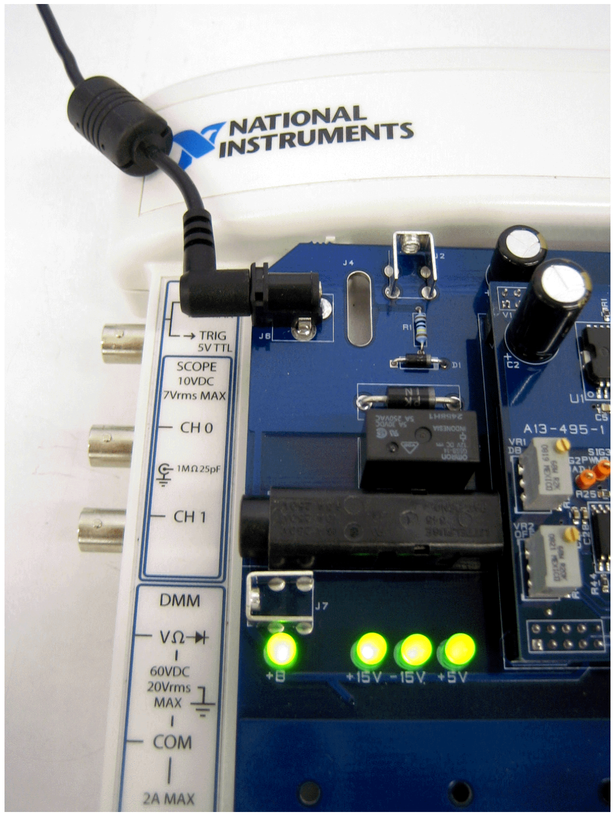

Figure 6.8: QNET LEDs should all be ON

6.2 QNET AND NI ELVIS SETUP

The procedure to install a Quanser Engineering Trainer (QNET) module on the traditional NI ELVIS (ELVIS I) is detailed in this section. An example of an installed system using the QNET DC Motor Control Trainer (DCMCT) module is pictured in Figure 6.9. Some of the components used in the installation procedure are located and marked by an ID number in Figure 6.9, and described in Table 6.

6.2.1 ELVIS Components

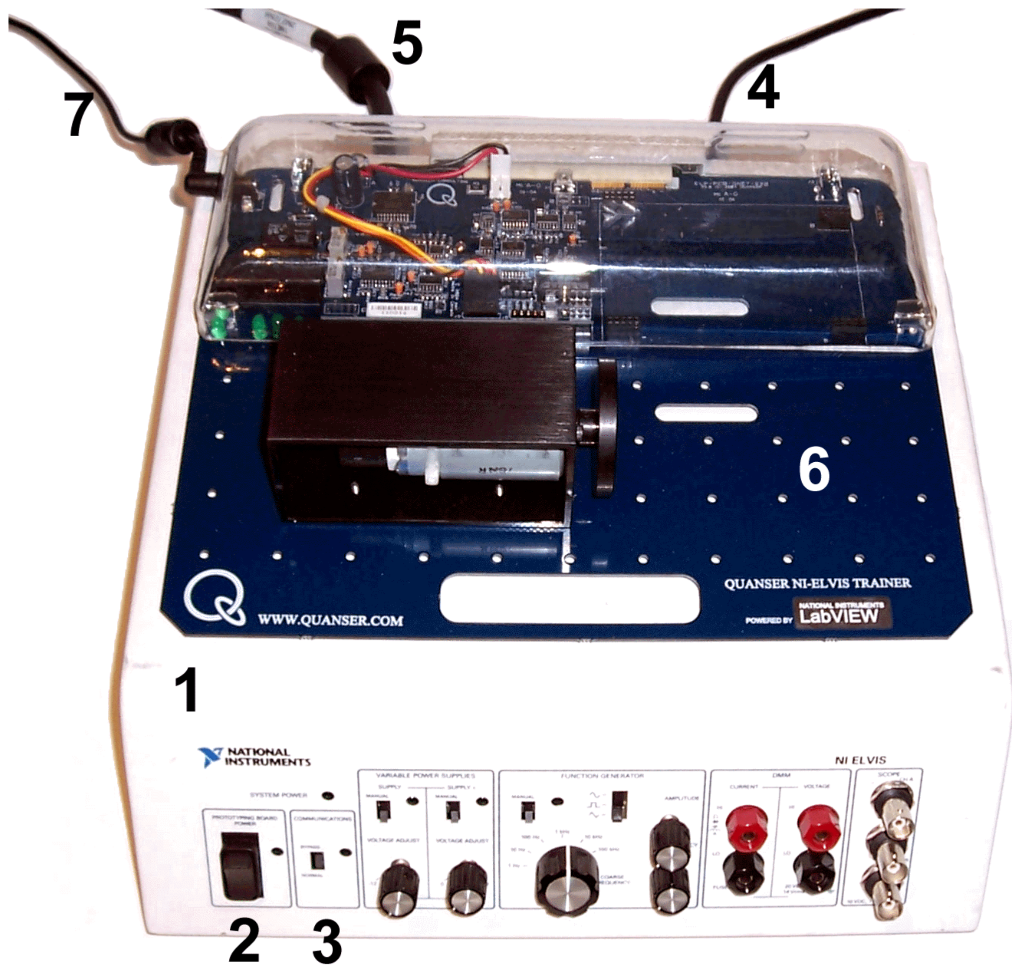

Figure 6.9: ELVIS and QNET setup components

ID#	Description	ID#	Description
1	NI ELVIS Benchtop Workstation (ELVIS I)	5	68-Pin E-Series or M-Series DACB Cable
2	Prototyping board power switch	6	QNET DCMCT
3	Communications Switch	7	QNET Power Cable
4	Power Cable for ELVIS I		

Table 6: ELVIS and QNET components

6.2.2 ELVIS Setup Procedure

Follow these instructions to setup a QNET board on an traditional ELVIS (ELVIS I):

■ **Caution: Do NOT make the following connections while power is supplied to the hardware!**

1. Place the small opening on the front of the QNET board over the mounting bracket on the NI ELVIS (note that some ELVIS workstations may not have mounting brackets).
2. Slide the PCI connector of the QNET module end into the female connector on the NI ELVIS. Make sure it is connected properly.
3. Connect the NI ELVIS power cable shown as ID #4 in Figure 6.9.
4. Connect the QNET power cable labeled ID #7 in Figure 6.9.

   Note: Not required for the QNET mechatronic sensors trainer.
5. Ensure the *Prototyping Board Power* switch, ID #2, is set to the OFF position and the *Communications* switch, ID #3, is set to the BYPASS mode.
6. Power the NI ELVIS Benchtop Workstation by turning the *Standby Switch* on the rear panel of the system to ON.
7. Turn ON the *Prototyping Board Power* switch.

   ■ **Caution: Turn OFF the *Prototyping Board Power* switch if**

   - On the QNET-DCMCT, QNET-ROTPENT, or QNET-VTOL Trainer the DC motor begins to turn
   - On the QNET-HVACT the halogen light turns on brightly

   Take extra care when powering the QNET module to avoid causing any damage!
8. The *System Power*, *Prototyping Board*, and *Communications* LEDs situated on the front panel of the NI ELVIS unit should all be lit.
9. As pictured in Figure 6.8, verify that the *+15V*, *-15V*, *+5V*, and *+B* LEDs on the QNET module are lit. They indicate that the board has been properly connected to the ELVIS unit.

   Note: For the QNET-MECHKIT, ensure the *+15V*, *-15V*, and *+5V* LEDs are lit (it does not require QNET power supply).

7 QNET LABVIEW HINTS

7.1 SCALING SCOPES

This section describes a handy method of changing the x or y axis in a LabVIEW scope using *QNET_DCMCT_Swing_Up_Control* VI as an example. Read the steps below to reduce the y-axis range of the Angle (deg) scope shown in Figure 7.10 in order to see the blue trace more up close.

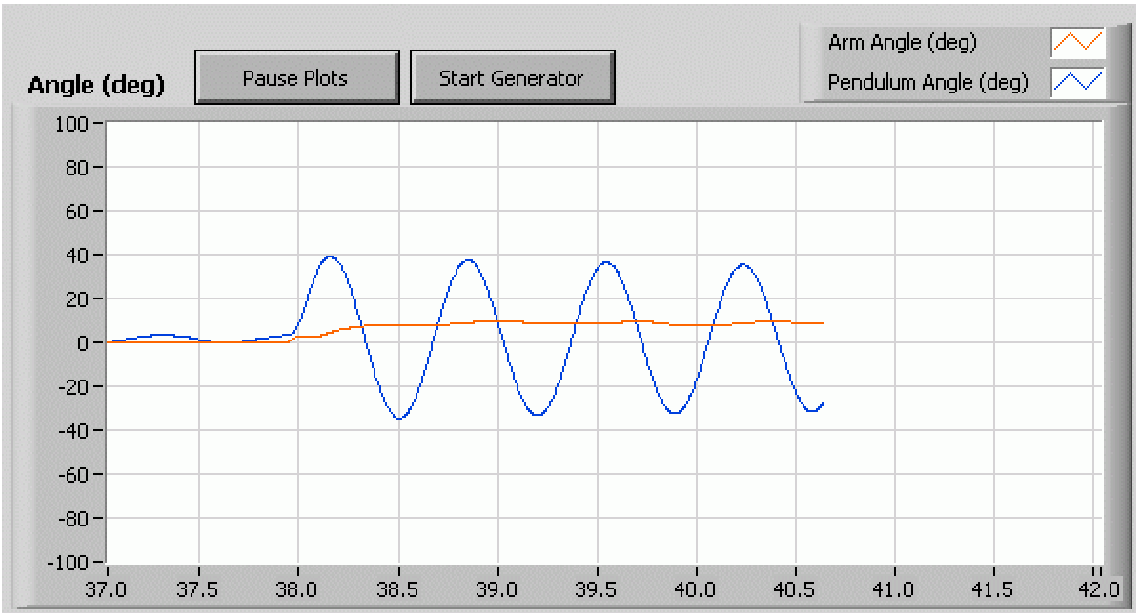

Figure 7.10: Scope needs to be scaled

1. As illustrated in Figure 7.11, to decrease the positive range of the scope down to 40, double-click on '100' in the y-axis, type in '40', and press ENTER.

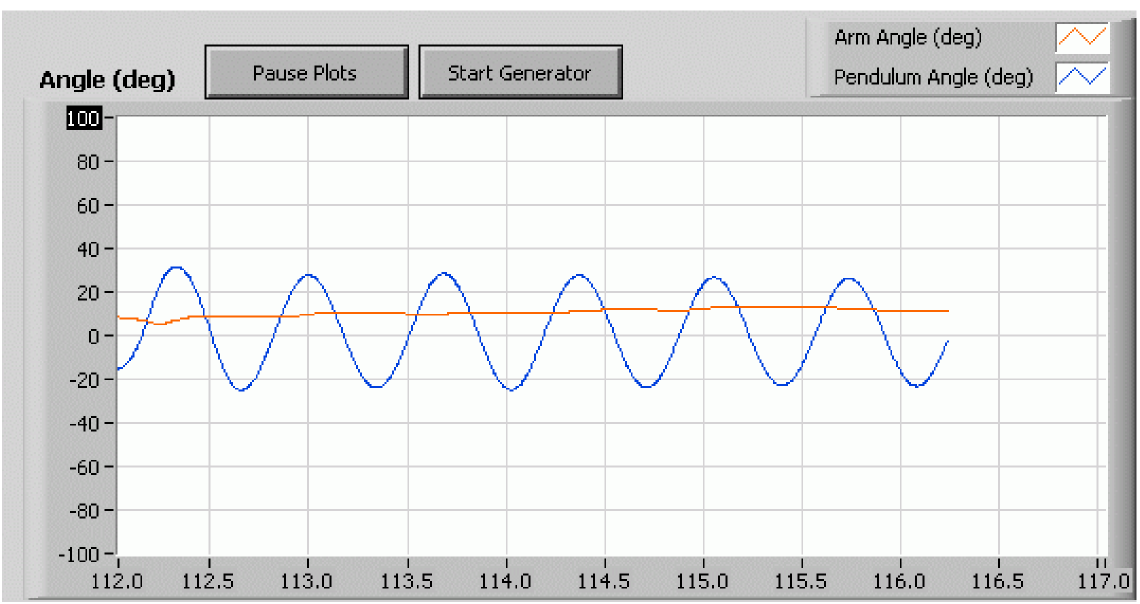

Figure 7.11: Changing scale of LabVIEW scope

2. The resulting scope is depicted in Figure 7.12. The blue trace is now more visible.

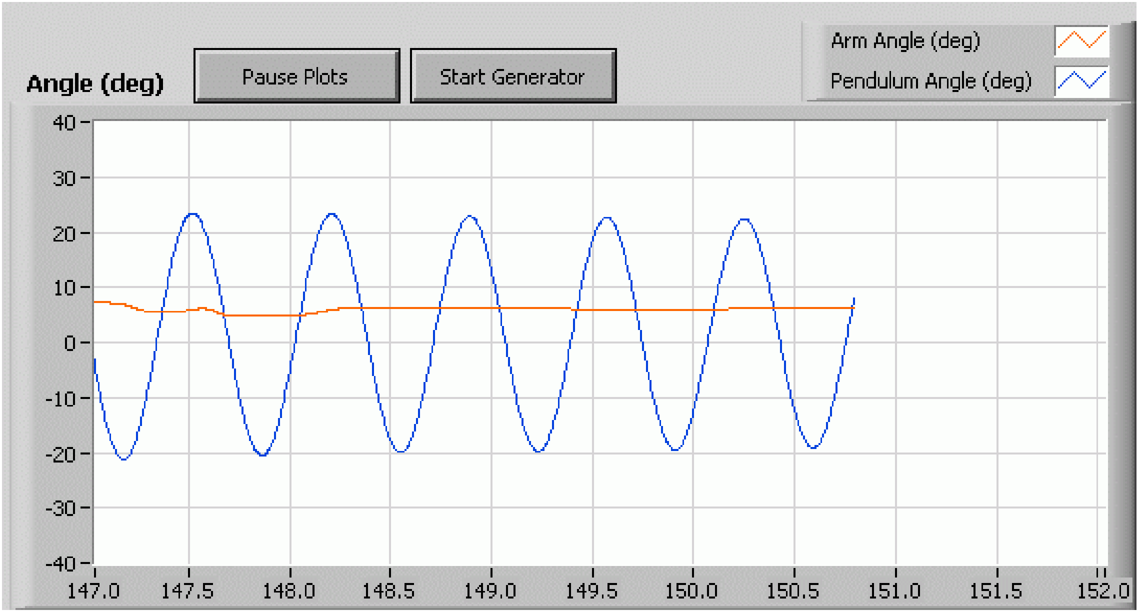

Figure 7.12: Y-axis of scope has been adjusted

Similarly, the minimum range of the y-axis can be changed as well as the range of the x-axis. For example, to see a time range of 10 seconds instead of 5 seconds the x-axis range can be changed from [0.0, 5.0] to [0.0, 10.0]. However, when changing the x -axis, i.e. the time-scale, it is recommended to do the following:

1. Pause the scopes or stop the VI and clear the chart (right-click on scope, select Data Operation | Clear Chart).
2. Apply the same scale change to both the output and input scopes. Otherwise, the data plotted in each scope will not be synchronized with each other.

7.2 SAVING RESPONSE

Read the following to save a scope response:

1. Right-click on the scope and select Export Simplified Image, as shown in Figure 7.13

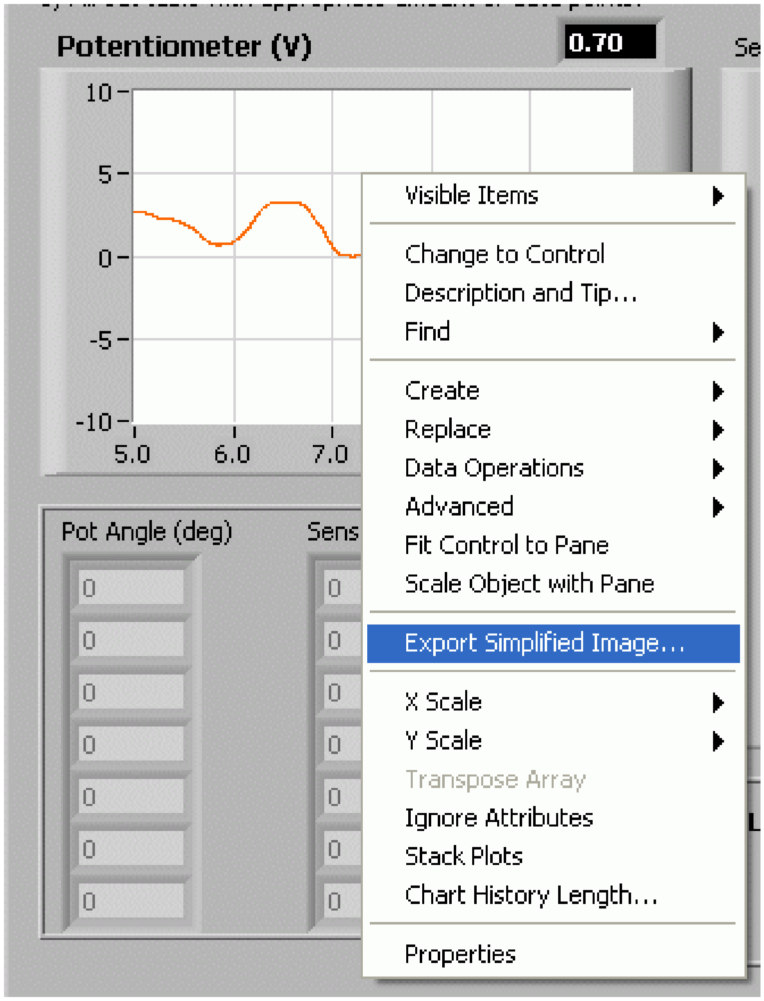

Figure 7.13: Right-click on scope and select Export Simplified Image

2. The dialog box shown in Figure 7.14 opens and gives various image export options. One way is to export the image to the clipboard as a bitmap. This can then be pasted in a graphical software (e.g MS Paint, Irfanview) and saved to a desired format (e.g. png).

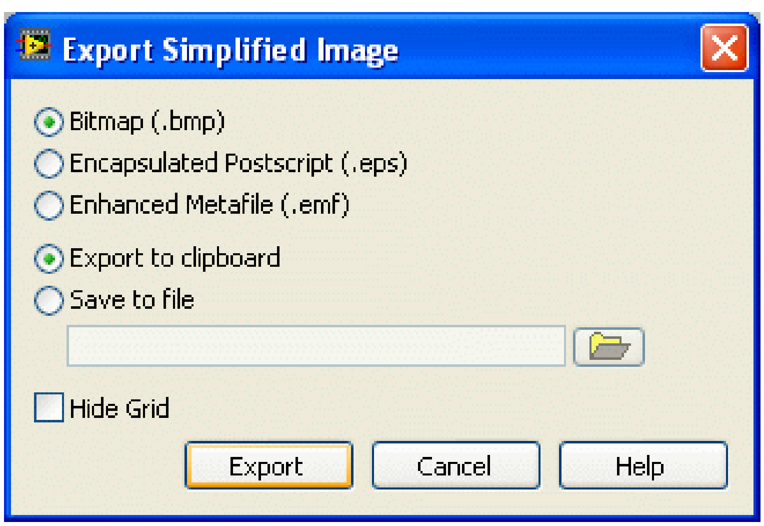

Figure 7.14: Export Simplified Image dialog box

3. The resulting image that is saved is shown in Figure 7.15.

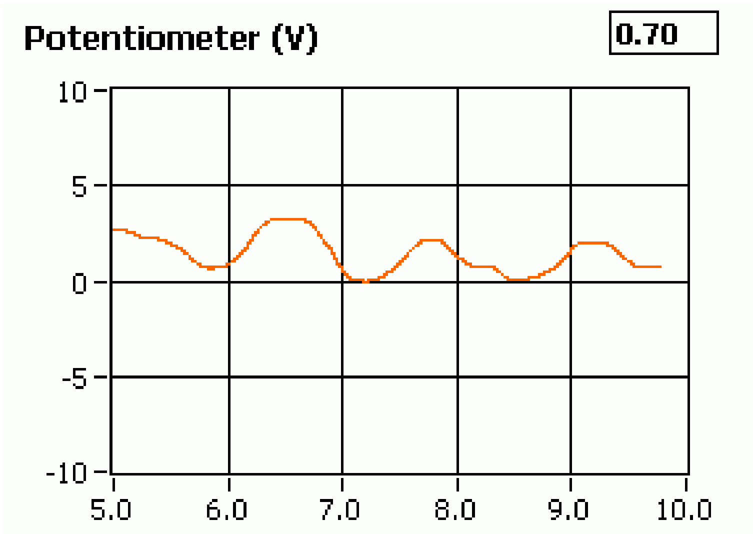

Figure 7.15: Sample saved response

The scope can be saved whether or not the VI is running. However, typically it is easier to stop the VI when the desired response is collected and then export the image as instructed above.

8 TROUBLESHOOTING

8.1 GENERAL SOFTWARE ISSUES

Q1 When I try to open a QNET VI, it says there are some missing VIs and they have a "CD" or "Sim" in the name?

The *LabVIEW Control Design and Simulation Module* is not installed.

□ □ □

Q2 When I open a QNET VI a message prompts that a VI with "ELVIS" in the name cannot be found?

- ELVIS I: The QNET VIs use drivers that are installed from the ELVIS 3.0 or later CD. Make sure it is installed. If the folder "\National Instruments\NI ELVIS 3.0" does not exist then it is not installed (available for download at `www.ni.com` as well).
- ELVIS II: The QNET VIs use the ELVISmx drivers. Make sure you install the contents of the ELVIS II CD before attempting to open any of the QNET VIs (available for download at `www.ni.com` as well).

□ □ □

8.2 GENERAL HARDWARE ISSUES

Q1 None of the LEDs on the QNET board are lit?

Make sure both the *System Power* switch, which is located on the back of the ELVIS I and II units, and the *Prototyping Board Power* switch, which is situated on the front panel of the ELVIS I and on the top-right corner of the ELVIS II, are ON. See the QNET Setup Guide for more information.

□ □ □

Q2 On the QNET board, the +15V, -15V, and +5V LEDs are bright green but the +B LED is not lit?

Ensure the QNET power connector on the QNET board is connected with the supplied QNET power cable. See the QNET Setup Guide for more information.

□ □ □

Q3 At least one of the +B, +15V, -15V, and +5V LEDs on the QNET board is not lit?

- See Q2 if only the +B is not lit.
- If one or more of the +15V, -15V, and +5V LEDs is not lit then a +/-15V or +5V fuse(s) on the *Protection Board* of the NI-ELVIS I is burnt. Similarly, if the +B LED is still not lit after connecting the QNET power then the *Variable Power Supplies Fuses* on the ELVIS *Protection Board* are burnt. See the *Protection Board Fuses* in the NI ELVIS User Manual and replace the fuses as directed.

□ □ □

Q4 The *Ready LED* on the ELVIS II does not go on?

1. Go through the ELVIS II setup procedure outlined in the QNET Setup Guide
2. Once completed, launch the *Measurement & Automation Explorer* software.
3. As illustrated in Figure 8.16, expand the *Devices and Interfaces* and *NI-DAQmx Devices* items and select the NI ELVIS II device.
4. As shown in Figure 8.16, click on the *Reset Device* button.
5. Once successfully reset, click on the *Self-Test* button.
6. If the test passed, reset the ELVIS II (i.e. shut off the *Prototyping Board* switch and *System Power* switch and turn them back on again). The *Ready LED* on the ELVIS II should now be lit.

□□□

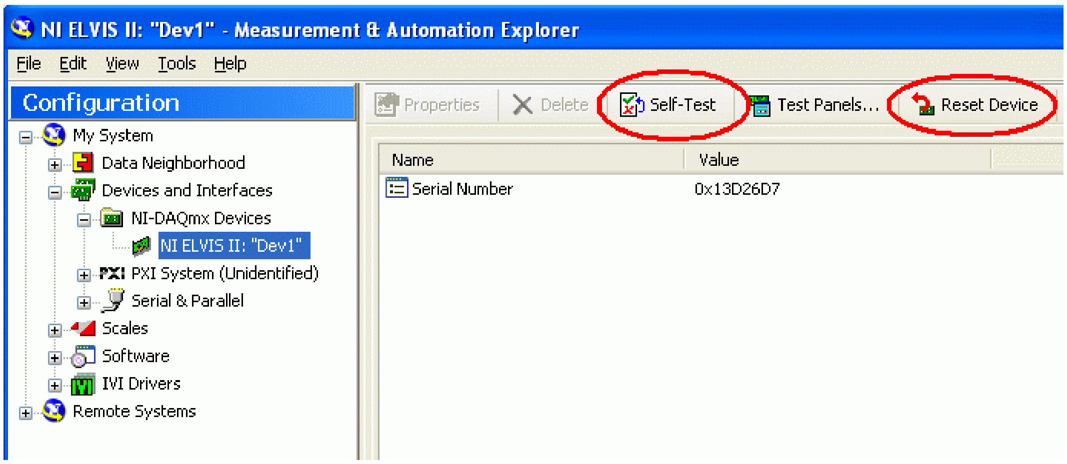

Figure 8.16: Reseting and performing the self-test on the ELVIS II

8.3 DCMCT ISSUES

Q1 When I open a QNET-DCMCT VI, the scopes are all reading '0' or near '0', as shown in Figure 8.17 below. Why are the scopes not responding when I manually move the disk load?

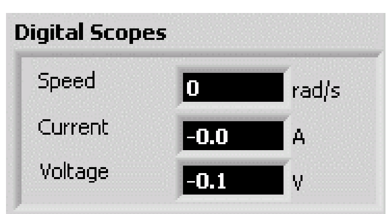

Figure 8.17: Scopes on speed-measuring QNET-DCMCT VIs

The *Prototyping Board* switch is not ON. The LED next to the switch should be bright green. Please review the QNET Steup Guide.

□□□

Q2 The motor does not move when I run the VI?

Ensure the QNET Power cable is connected. The four LEDs +B, +15V, -15V, and +5V on the QNET board should all be bright green.

□□□

9 TECHNICAL SUPPORT

To obtain support from Quanser, go to http://www.quanser.com/ and click on the Tech Support link. Fill in the form with all the requested software and hardware information as well as a description of the problem encountered. Also, make sure your e-mail address and telephone number are included. Submit the form and a technical support person will contact you.