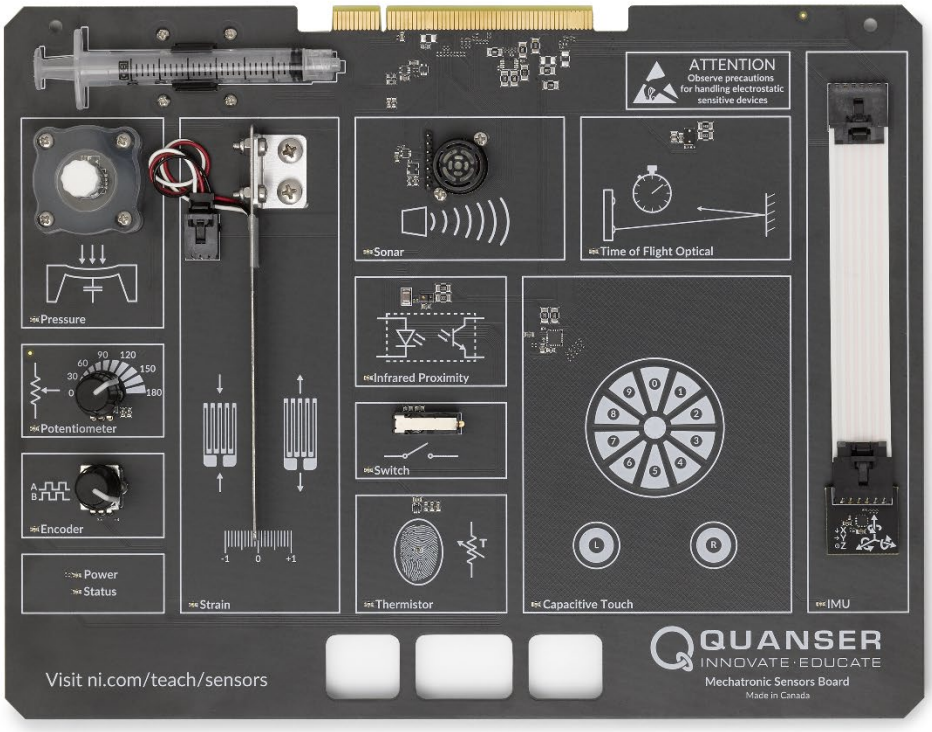
User Manual

Quanser Mechatronic Sensors Board for NI ELVIS III



Setup and Configuration

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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 Mechatronic Systems Board

The Quanser Mechatronic Sensors Board, pictured in Figure 1, is an application board designed for teaching and demonstrating the fundamentals of common sensors used in mechatronic applications. It provides students hands-on experience measuring, calibrating, and analyzing the following physical properties/phenomenon: contact, angular displacement, distance and proximity, pressure, strain, temperature and inertial measurements. The system is operated using a PC running LabVIEW 2018, and the NI ELVIS III.

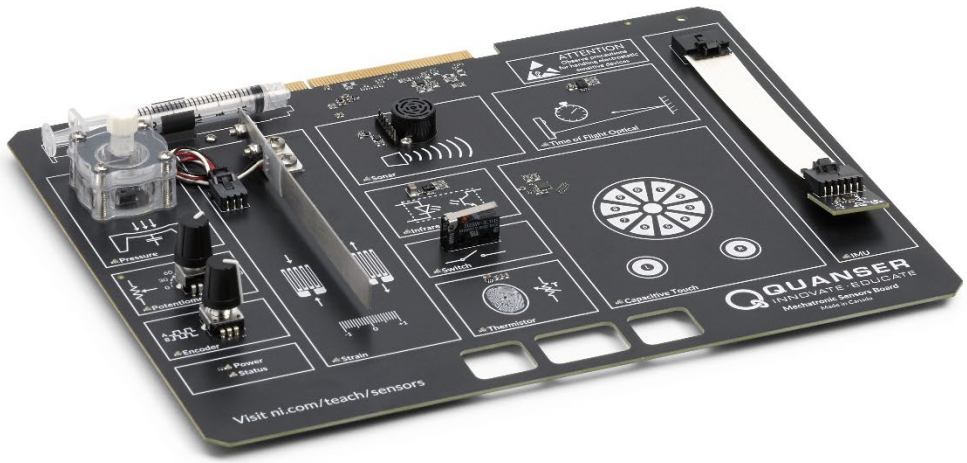

Figure 1: The Quanser Mechatronic Sensors Board

Main Features

- Capacitive pressure transducer
- Potentiometer
- Quadrature encoder
- Strain gage (quarter-bridge type II) mounted on a cantilever beam
- Ultrasonic/sonar distance sensor
- Infrared (IR) proximity sensor
- Snap-action switch
- Thermistor
- Time-of-Flight distance sensor
- Capacitive touch sensor
- 9-axis IMU sensor

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

The interaction between the NI ELVIS III and the different system components on the Quanser Mechatronic Sensors Board is illustrated in Figure 2. The Sensors board is interfaced to the NI ELVIS III via a PCI connector.

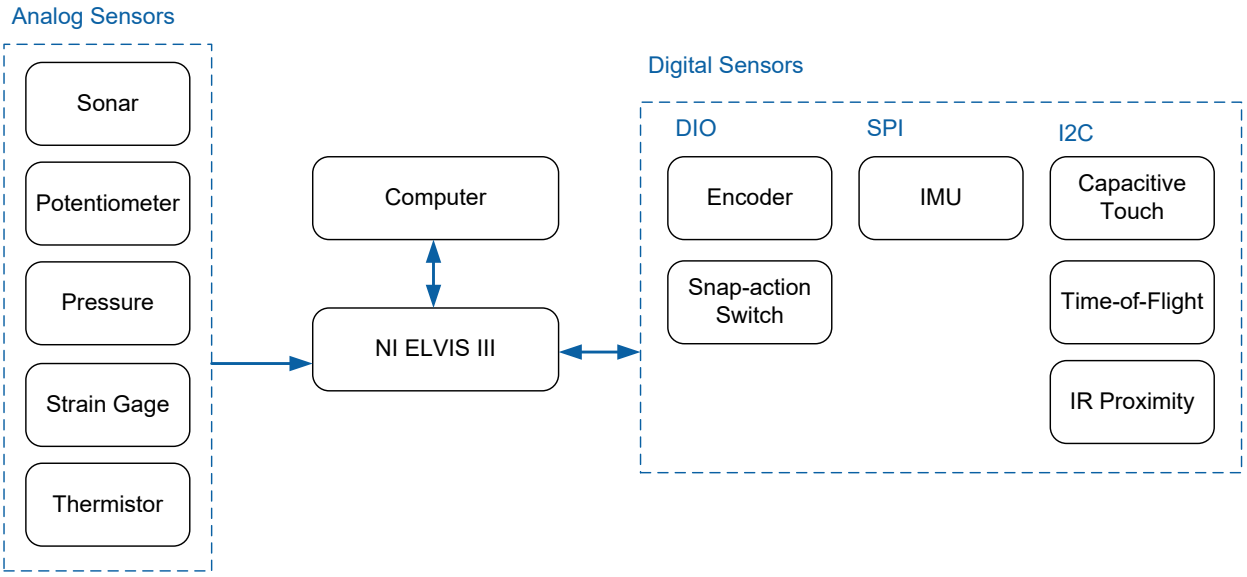

Figure 2: Interaction between the board and the NI ELVIS III

Hardware Components

The main components of the Quanser Mechatronic Sensors Board are labeled in Figure 3, and listed in Table 1.

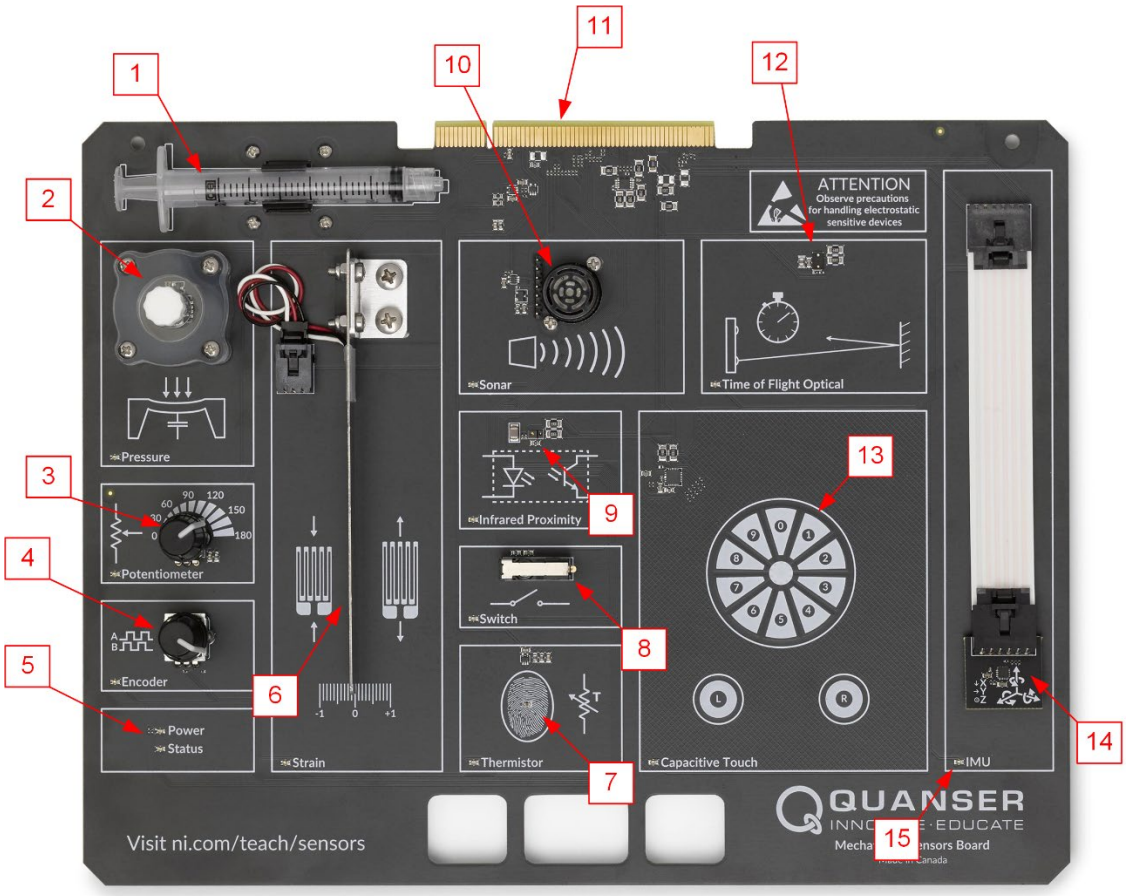

Figure 3: Quanser Mechatronic Sensors Board components

Table 1: Sensors board hardware components

ID	Component	ID	Component
1	Syringe with Luer lock	9	Infrared proximity sensor
2	Pressure transducer; chamber	10	Sonar
3	Potentiometer	11	PCI connector
4	Quadrature encoder	12	Time-of-Flight distance sensor
5	Power and Status LEDs	13	Capacitive touch sensor; pad
6	Cantilever beam with strain gage	14	9-axis IMU sensor
7	Thermistor	15	Sensor-specific status LED
8	Snap-action switch		

ESD Warning

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

Strain gage

As shown in Figure 4, the strain gage is configured in a quarter bridge type II Wheatstone bridge circuit. As stated in Table 2, the strain gage has a nominal resistance of 350 ohm, an average gage factor of 2, and is excited using a 5 V DC supply. The gage is mounted on a cantilever beam. A linear scale is printed on the board, which can be used to measure linear displacement of the beam's tip.

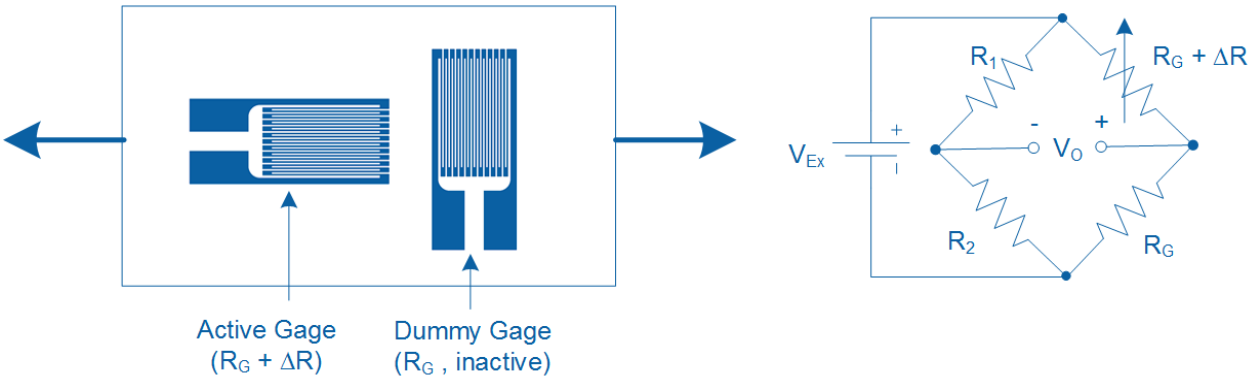

Figure 4: Quarter bridge type II circuit

Pressure transducer

The pressure transducer is a miniaturized analog barometric air pressure sensor IC based on a capacitive principle. As stated in Table 2, the pressure transducer has a range of 60 kPa to 165 kPa, an accuracy of ±2 kPa. The transducer is housed inside a chamber which has a male Luer lock connector. The pressure chamber has a dead volume of approximately 5 mL.

Syringe

A 3 mL syringe with a female Luer lock connector is supplied. The syringe can be used to increase or decrease air pressure inside the pressure chamber.

Thermistor

The thermistor is mounted on the surface of the Quanser Mechatronic Sensors Board at the center of the fingerprint image. As stated in Table 2, it has a resistance of 47,000 ohm at 25 °C. The circuit shown in Figure 5 is used to measure the output of the sensor, where R_T is the variable resistance of the thermistor.

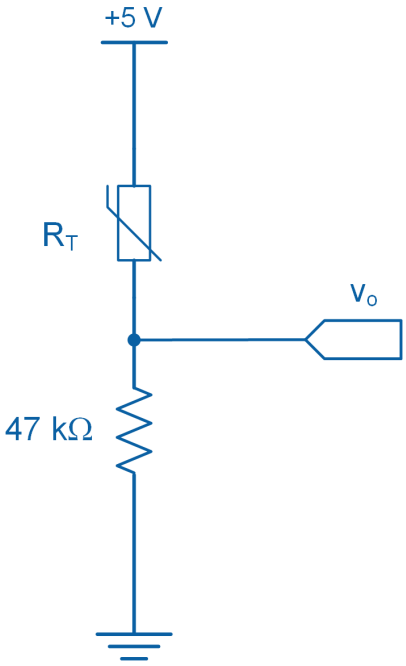

Figure 5: Thermistor circuit

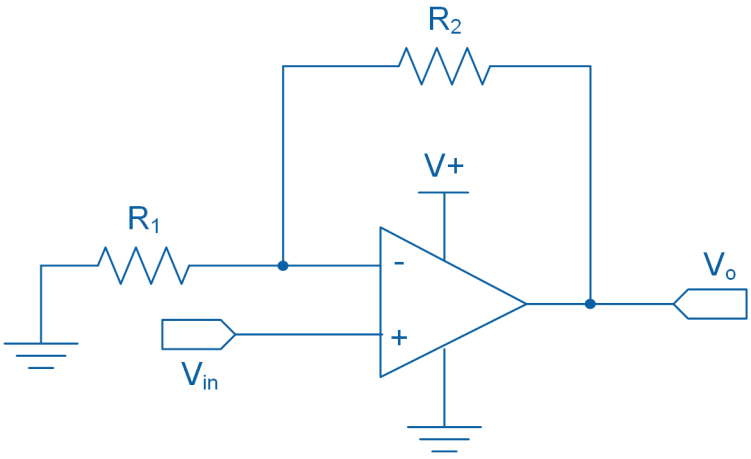

Figure 6: Non-inverting amplifier circuit diagram for the sonar

Time-of-Flight Sensor

The ToF sensor used in this application board incorporates a Class 1 eye-safe 850 nm Vertical Cavity Surface Emitting Laser (VCSEL). It can sense objects between 100 mm and 2000 mm and directly outputs an 11-bit value ranging between 0 and 2048, which directly corresponds to the target distance in millimeters.

Sonar/ultrasonic distance sensor

The application board uses a MaxBotix sonar/ultrasonic distance sensor with an operating measuring range of 15.24 cm to 645.16 cm and a resolution of ±2.54 cm. The sensor points in the upward direction for easy comparison with the Time-of-Flight sensor. It outputs a voltage that correlates to the distance of the target. Best sensitivity is obtained when the sensor's detection area is clear of any objects for 35.56 cm during power-up. For correct operation of the sonar, the application board must be placed 1 m away from any vertical walls. The non-inverting amplifier circuit shown in Figure 6 amplifies the output of the sonar. Resistor R_1 = 10 kΩ and R_2 = 10 kΩ determine the gain of the amplifier as follows: $G = 1 + R_2 / R_1$.

Infrared proximity sensor

The application board uses a Broadcom APDS-9190 digital IR proximity sensor. The user can set the number of IRED pulses (between 1 and 255) generated by the sensor during each cycle of operation. Each pulse has a period of 16.3 μs. A higher number of pulses increases the sensitivity of the sensor. The sensor outputs a count value ranging between 0 and 1023. The value depends on the distance of the target and is a measure of the amount of reflected IR light. A count value of 1023 means the target has reached the proximity detection threshold of the sensor. Once the output saturates at 1023 counts, it will not increase even if the target moves closer to the sensor.

IMU

The application board incorporates a TDK InvenSense MPU-9250 9-axis Inertial Measurement Unit (IMU) sensor. It consists of a 3-axis gyroscope, a 3-axis accelerometer, and a 3-axis magnetometer. Table 2 outlines the measurement ranges of the sensor. Figure 7 illustrates the orientation of axes of sensitivity and polarity of rotation for the accelerometer and gyroscope. Figure 8 illustrates the orientation of axes of sensitivity for the magnetometer. These orientations are silk screened on the IMU circuit board for easy reference during operation. The sensor is connected to the application board using a flat flexible cable.

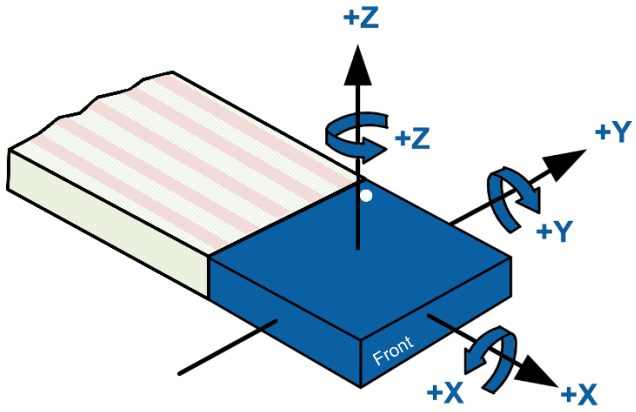

Figure 7: Orientation of axes of sensitivity and polarity of rotation for the accelerometer and gyroscope

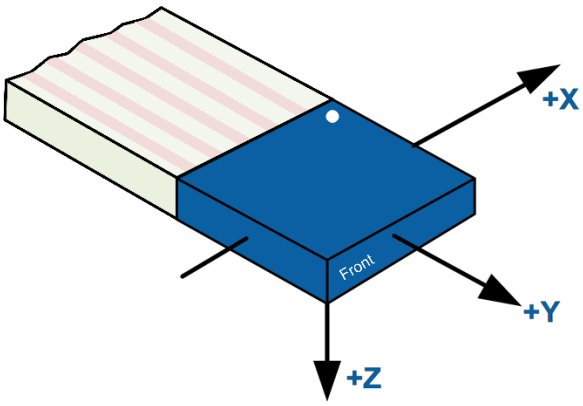

Figure 8: Orientation of axes of sensitivity for the magnetometer

Potentiometer

The rotary potentiometer outputs a voltage that varies linearly with the angle being measured. As listed in Table 2, the potentiometer has a mechanical limit of 280 degrees.

Encoder

The encoder operates in quadrature mode and outputs signals A and B. The encoder generates 24 pulses-per-revolution.

Snap-action switch

The digital output line connected to the snap action switch is pulled high, to +5 V, when the switch is in open position and goes down to low when pressed down.

Capacitive touch sensor

The application board incorporates a Cypress CY8CMBR3116-LQXI capacitive sensor with an I^2C interface. The sensor includes a circular touch pad that is divided into ten sectors labeled 0 to 9, as well as two individual buttons labeled L and R. The sensor converts capacitance into a digital count ranging between 0 and 255. An output of 0 indicates zero finger capacitance, while an output of 255 indicates the maximum measurable capacitance typically induced when a finger makes contact with the touchpad. The sensitivity of the sensor is set to 50 counts/0.1 pF.

Environmental

The Quanser Mechatronic Sensors Board is designed to function under the following environmental conditions:

- Standard rating
- Indoor use only
- Temperature 5 °C to 40 °C
- Altitude up to 2,000 m
- Maximum relative humidity of 80% up to 31 °C decreasing linearly to 50% relative humidity at 40 °C
- Pollution Degree 2
- Mains supply voltage fluctuations up to ±10% of nominal voltage
- Maximum transient overvoltage 2,500 V
- Marked degree of protection to IEC 60529: Ordinary Equipment (IPX0)

Caution

Ensure the unit is operated under the stated temperature and humidity conditions. Otherwise, there may be issues with the heating and cooling results.

System Parameters

Some of the sensor specifications are given in Table 2.

Table 2: Sensors board system parameters

Description	Value	Unit
Strain gage		
Nominal resistance	350 ± 0.2%	ohm
Average gage factor	2	
Time-of-Flight		
Sensing distance	10 ~ 200	cm
Output type	I^2C	
Pressure transducer		
Pressure range	60 to 165	kPa
Accuracy	±2	kPa
Thermistor		
Nominal resistance at 25 °C	47,000 ± 5%	ohm
Sonar/ultrasonic distance		
Distance measuring range	15.24 to 645.16	cm
Resolution	±2.54	cm
Infrared proximity sensor		
Distance measuring range	up to 100	mm
Infrared peak wavelength	850	nm
Output type	I^2C	
IMU		
3-axis gyroscope range	±250, ±500, ±1000, and ±2000	deg/sec
3-axis accelerometer range	±2, ±4, ±8, and ±16	g
3-axis magnetometer range	4,800	μT
Output type	SPI	

Potentiometer		
Mechanical angle range	280	deg
Resistance	10,000	ohm
Capacitive touch		
Circular scroll pad	9	Segments
Single-touch buttons	2	
Output type	I^2C	
Encoder		
Resolution	24	PPR
Number of channels	2 (signal A and B)	
Output type	Quadrature	

System Setup

The components of the NI ELVIS III are shown in Figure 9 and detailed in Table 3. The procedure to set up the Quanser Mechatronic Sensors 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.

Table 3: NI ELVIS III board 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

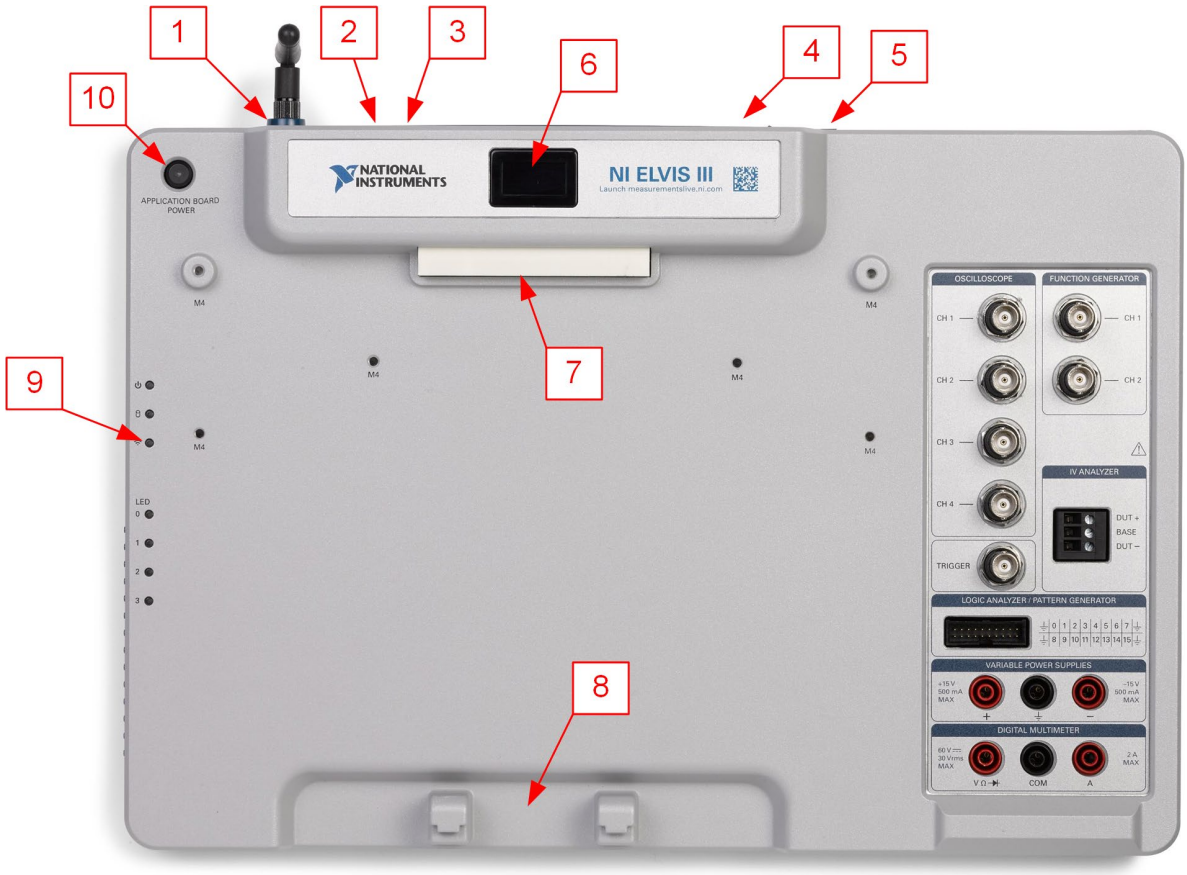

Figure 9: Components of the NI ELVIS III

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. Press the application board power button and ensure the LED on the button is lit
8. Ensure the *Power* LED on the application board is on.
9. Unscrew the protective cap from the pressure sensor chamber. Keep the protective cap in a safe place and use it for long term storage of the board.
10. Remove the syringe from the holder located on the board.
11. Attach the syringe to the Luer lock connector on the pressure sensor chamber by gently twisting the syringe in the clockwise direction.

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

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

The *Power* LED on the application board is not lit

1. Ensure that the PCI connector on the Quanser Mechatronic Sensors Board is properly connected to the female connector on the NI ELVIS III.
2. Ensure the power switch located on the back panel of the NI ELVIS III is ON.
3. Ensure the application board power switch located on the top of the NI ELVIS III is ON.

Sensors are giving incorrect readings

1. Ensure that only one Quanser Mechatronic Sensors Board VI is running at a given time.
2. Ensure that the *Initialized?* LED in the VI turns on before conducting any experiments.