QUADRA™ USER MANUAL

USB- & Battery-Powered Multi Frequency Electrical Impedance Spectroscopy Device

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Patents

The device and methods described in this document are covered by following patents: The Estonian Patent Office - KASULIKU MUDELI KIRJELDUS EE01312U1 – “Modular system for the measurement of the electrical impedance”; P201500014 – “Binaarse ergutusega impedantsi analüsaatori meetod ja seade”. Method and device for broadband analysis of systems and substances US13/598955

Disclaimer

Refer to EULA.TXT document in Quadra Software Package.

Abbreviations

DSP	Digital Signal Processor
POT	Digital Potentiometer
PGA	Programmable Gain Amplifier
OSC	Oscillator
I2C	Inter-Integrated Circuit Serial Bus
GUI	Graphical User Interface
ADC	Analog to Digital Converter
IO	Input Output
LED	Light Emitting Diode
HEX	Hexadecimal Number
GPIO	General Purpose Input Output
USB	Universal Serial Bus
AFE	Analog Front-End
RAM	Random Access Memory
MEX	Matlab dynamically linked executable
DFT	Discrete Fourier Transform

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Introduction

This user manual contains specifications and instructions only for the Quadra device and its Windows based client software. Every application requires an application specific analog front-end, the instructions for analog front-ends are provided separately.

System Overview

Quadra device requires USB connection to a host PC for power supply (alt. battery charging) and data transmission, see **Figure 1**. The control commands and measurement data flow are controlled by *Quadra Control Panel* GUI that operates the device using a Microsoft *WinUSB* driver. In order to make impedance measurements, an application specific analog front-end is required. The front-end connects to measurement electrodes and provides signal conditioning for Quadra device.

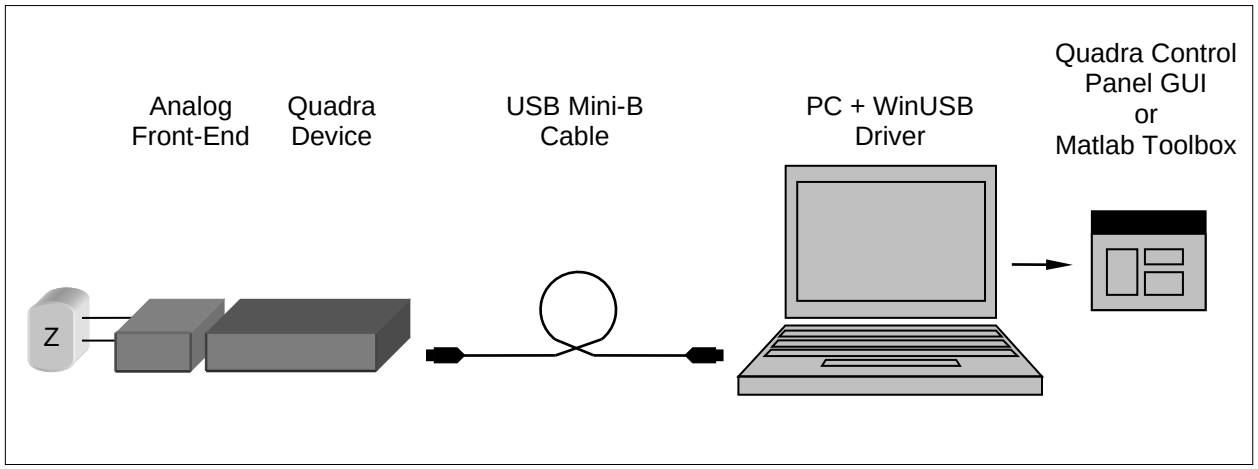

Figure 1 Components of Quadra based Impedance Acquisition System

Quadra is a real time electrical impedance spectroscopy device which is capable of measuring a spectrogram of 15 frequencies with speed of 1000 measurements per second. The compact enclosure includes all the circuitry required to generate spectrally sparse excitation voltage and to measure the response voltage and current (**Figure 2**). The measured response current and voltage time domain signals are used as input to calculate the spectra values for both module and phase at every frequency point. The calculated spectra will be transmitted to PC application for displaying and/or logging. To guarantee lower noise levels and to limit possibility of excitation current leak during the measurements the device has integrated battery with battery management hardware and software. In battery-powered mode, the ground and supply are disconnected from USB bus, the USB data and *SYNC* lines are optically decoupled.

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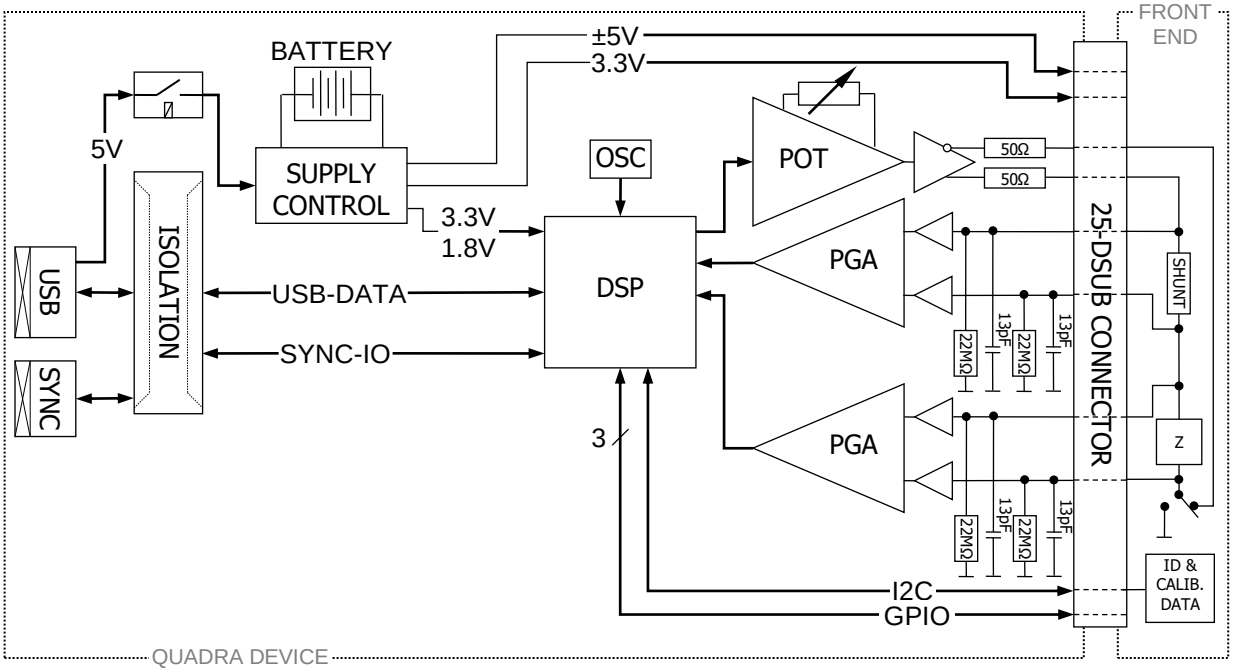

Figure 2 Quandra Internal and External Components

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Device Specifications

Table 1 Measurement Parameters

Parameter	Value(s)
Impedance	Relative value of impedance. Module in units of ohms and phase in units of degrees.
Number of Frequencies in Spectrogram	15
Spectrogram Acquisition Period	1 ms; 1.8 s during Minimum Spectrogram Frequencies configuration.
Maximum Spectrogram Frequencies	1.0000 kHz, 2.0000 kHz, 3.0000 kHz, 7.0000 kHz, 11.0000 kHz, 17.0000 kHz, 23.0000 kHz, 31.0000 kHz, 43.0000 kHz, 61.0000 kHz, 89.0000 kHz, 127.0000 kHz, 179.0000 kHz, 251.0000 kHz, 349.0000 kHz
Minimum Spectrogram Frequencies	0.5580 Hz, 1.1160 Hz, 1.6741 Hz, 3.9062 Hz, 6.1383 Hz, 9.4866 Hz, 12.8348 Hz, 17.2991 Hz, 23.9955 Hz, 34.0401 Hz, 49.6651 Hz, 70.8705 Hz, 99.8883 Hz, 140.06697 Hz, 194.7544 Hz
Repeatability, Resolutions	0.1 %, 12-Bit ADC's, 16-Bit DFT references

Table 2 Technical Parameters

Parameter	Value(s)
Excitation Waveform	Binary Multi Frequency
Number of Excitation Channels	1
Excitation Channel Type	Differential, 50 Ω
Excitation Channel Voltage Level, Offset	0.4 Vpp to 7.5 Vpp, DC Offset 0 V
Number of Excitation Channel Voltage Level Steps	255
Number of Measurement Channels	2
Measurement Channels Type, Input Impedance	Differential, > 10 MΩ
Measurement Channels Input Range	3 Vpp @ PGA G=1
Measurement Channels Preamplifier Gains	1x, 2x, 5x, 10x
USB Bus Speed Settings, Standards	12 Mbps, Full Speed, USB 1.0, USB 2.0, USB 3.0
Power Consumption from USB Bus, Battery Duration	500 mA 2.5 W, 8 hours
Synchronization IO SMA Levels, Output Syncro Type	3.3 V CMOS, Output 1 ms Toggle, 5 V Tolerant, 50 Ω
Analog Front-End Digital IO	3x GPIO, I2C (400 kHz)
Analog Front-End Digital IO Levels	3.3 V CMOS, Not 5 V tolerant
Analog Front-End Digital & Analog Supply	3.3 V 150 mA, +5 V 150 mA, -5 V 100 mA

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Installing Device Drivers

Requirements for host PC

Free USB 2.0 or 3.0 port required. Supported operating systems are Windows XP 32-bit SP2[2], Windows XP 64-bit SP3[2], Windows 7 32-bit, Windows 7 64-bit, Windows 8 32-bit, Windows 8 64-bit, Windows 10 32-bit, Windows 10 64-bit.

[2] Driver installation requires self-signed certificate. Contact Eliko if driver installer for Windows XP is required.

Before Install

Unpack the software package retrieved from Eliko's web page or from supplied memory stick. For driver installation all the required drivers and tools for all Windows versions are located at *Quadra Software Package v1.1\Windows Drivers*\ subfolder.

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Installing Driver with Package Installer

1. Before installation, make sure that the device is not connected to PC USB port. Go to subfolder *Quadra Software Package v1.1\Windows Drivers* and start driver installation application *QuadraUSBDriverInstaller_v1.1.EXE*.

2. To start the driver installation, click *Next* on the driver installer dialog window.

Figure 3 Driver installer dialog

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3. On the EULA window (**Figure 4)** select *I accept EULA* if you accept displayed license agreement. Click *Next* to continue with driver installation.

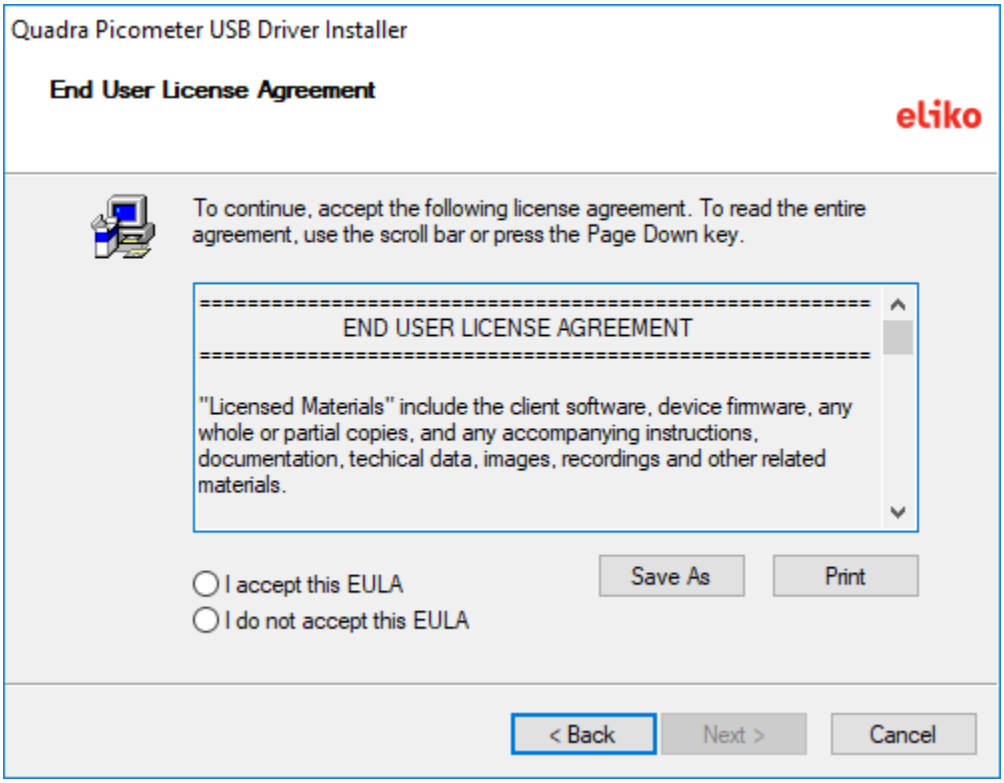

Figure 4 Driver EULA dialog

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4. If driver installation was successful, the confirmation dialog (**Figure 5**) will appear. Click *Finish* to close driver installation application. Now the device can be connected to the PC. After connecting the device for the first time, Windows will finish up driver installation.

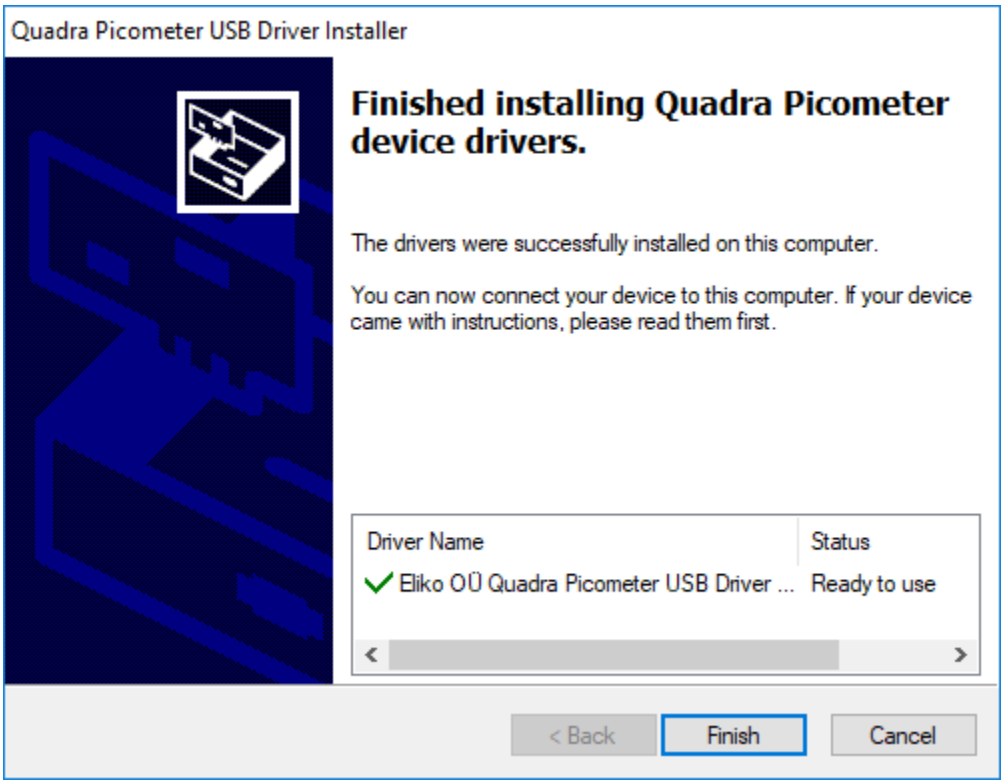

Figure 5 Driver installation confirmation dialog

NOTE:

The user can start Windows uninstaller program that can be used to uninstall the device driver. Locate *Windows Driver Package - Eliko OÜ Quadra Picometer USB Driver* under the Windows *Programs and Features* in *Control Panel* and choose *Uninstall/Change* from the context menu.

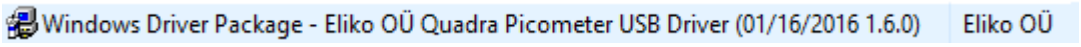

Figure 6 Quadra USB driver package in Programs and Features

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Manual Driver Installation

The next steps are not required if driver was already successfully installed in previous steps.

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Procedure for Windows 8 and Windows 10

1. To start with driver installation, connect the Quadra device to a USB port. At initial connection, Windows is unable to locate drivers for the device. Open device manager by typing *Device manager* in Windows *Start Screen*. Locate device named as *Quadra Picometer* under *Other devices* in the *Device Manager*. Right-click and choose *Properties* to open device properties window and on *General tab*, click *Update Driver* as shown on **Figure 7**. In the next dialog, select *Browse my computer for driver software* (**Figure 8**). Browse for the folder *\Windows Drivers\Eliko Install Disk v1.6.0* in the Quadra software package (**Figure 9**). If driver installation finishes successfully, then the confirming dialog (Figure 10) will be displayed.

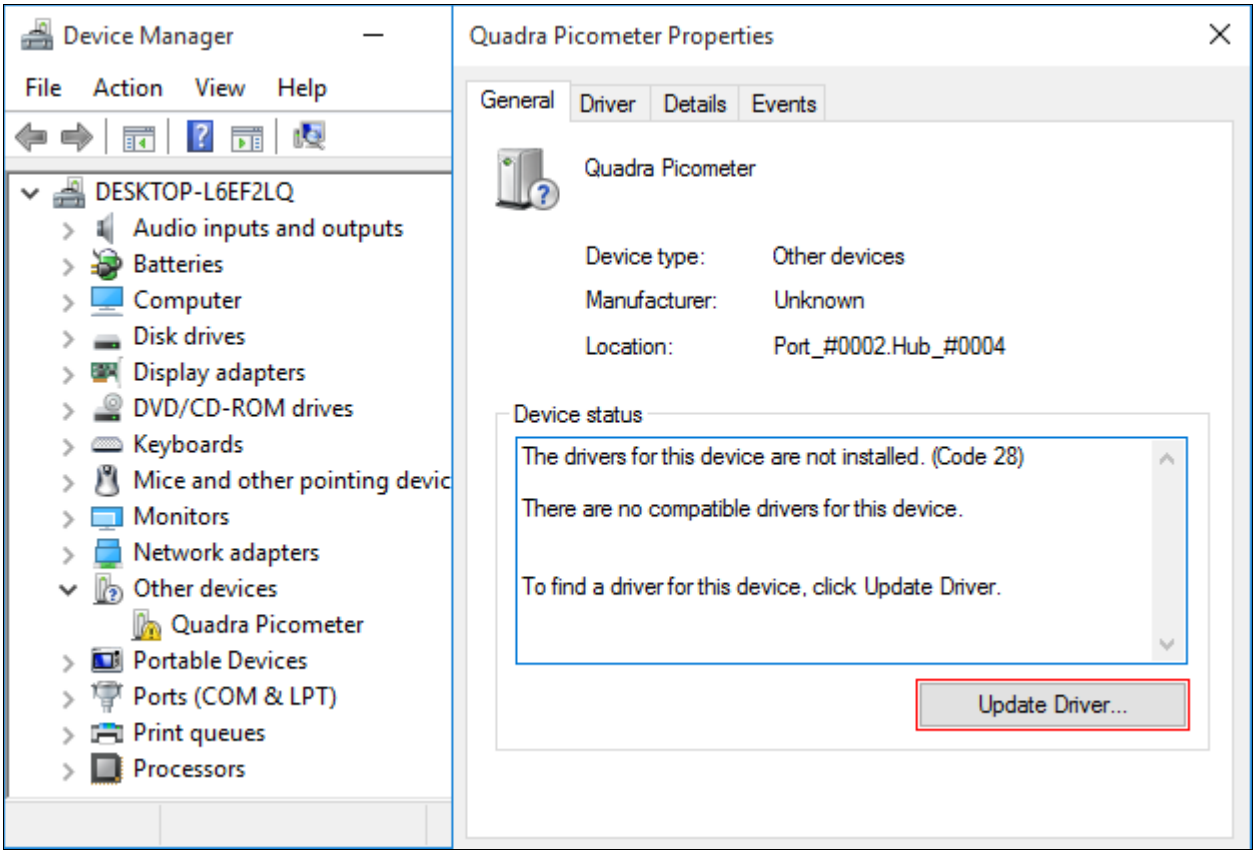

Figure 7 Update Device Drivers from Device Manager

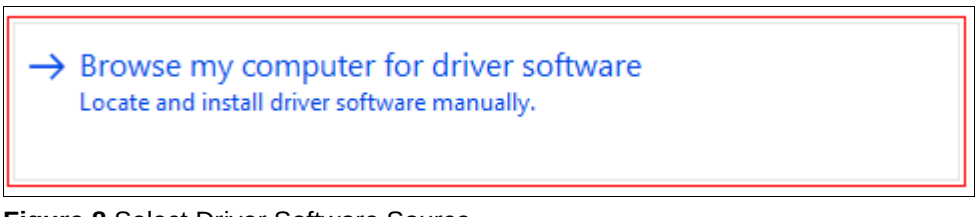

Figure 8 Select Driver Software Source

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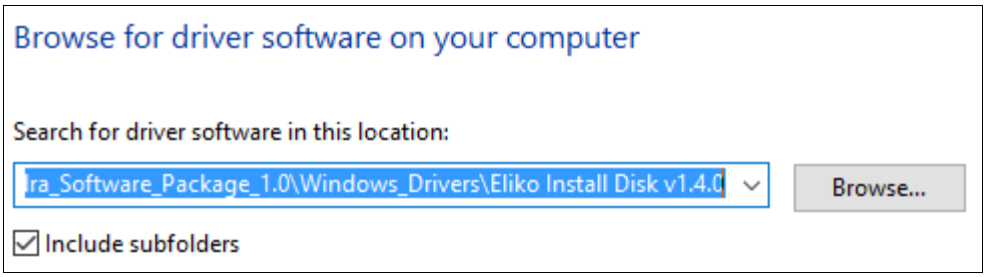

Figure 9 Select Device Drivers Folder

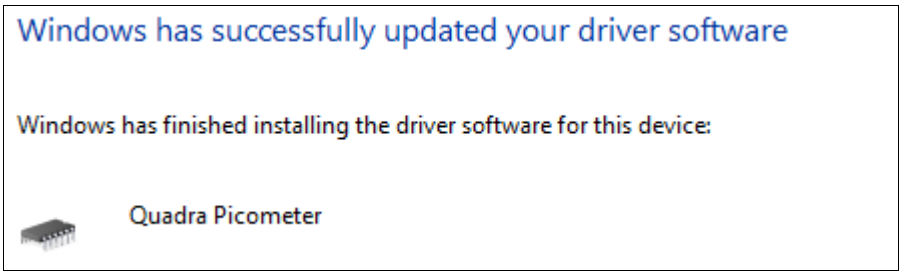

Figure 10 Device Driver Install Finished

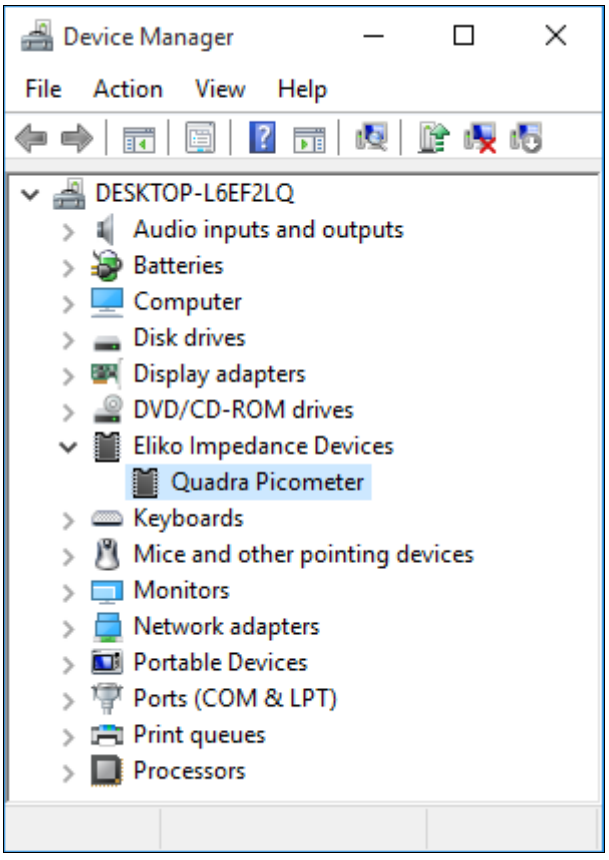

Figure 11 Device Ready Under Device Manager

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Procedure for Windows XP and Windows 7

To start with driver installation, connect the Quadra device with PC USB port. At initial connection, Windows is unable to locate drivers for the device. Open *Device Manager* and under *Other devices* locate the Quadra device named as *Quadra Picometer* (**Figure 12**). Open device properties window and under *General tab* click *Update Driver...* or *Reinstall Driver...* as shown on **Figure 13**. On the first dialog, select *Browse my computer for driver software* and on Windows XP select *No, not this time* and *Install from list or specific location* (**Figure 14**). On the next dialog, browse for the folder *\Windows Drivers\Eliko Install Disk v1.6.0* in Quadra software package (**Figure 15**).

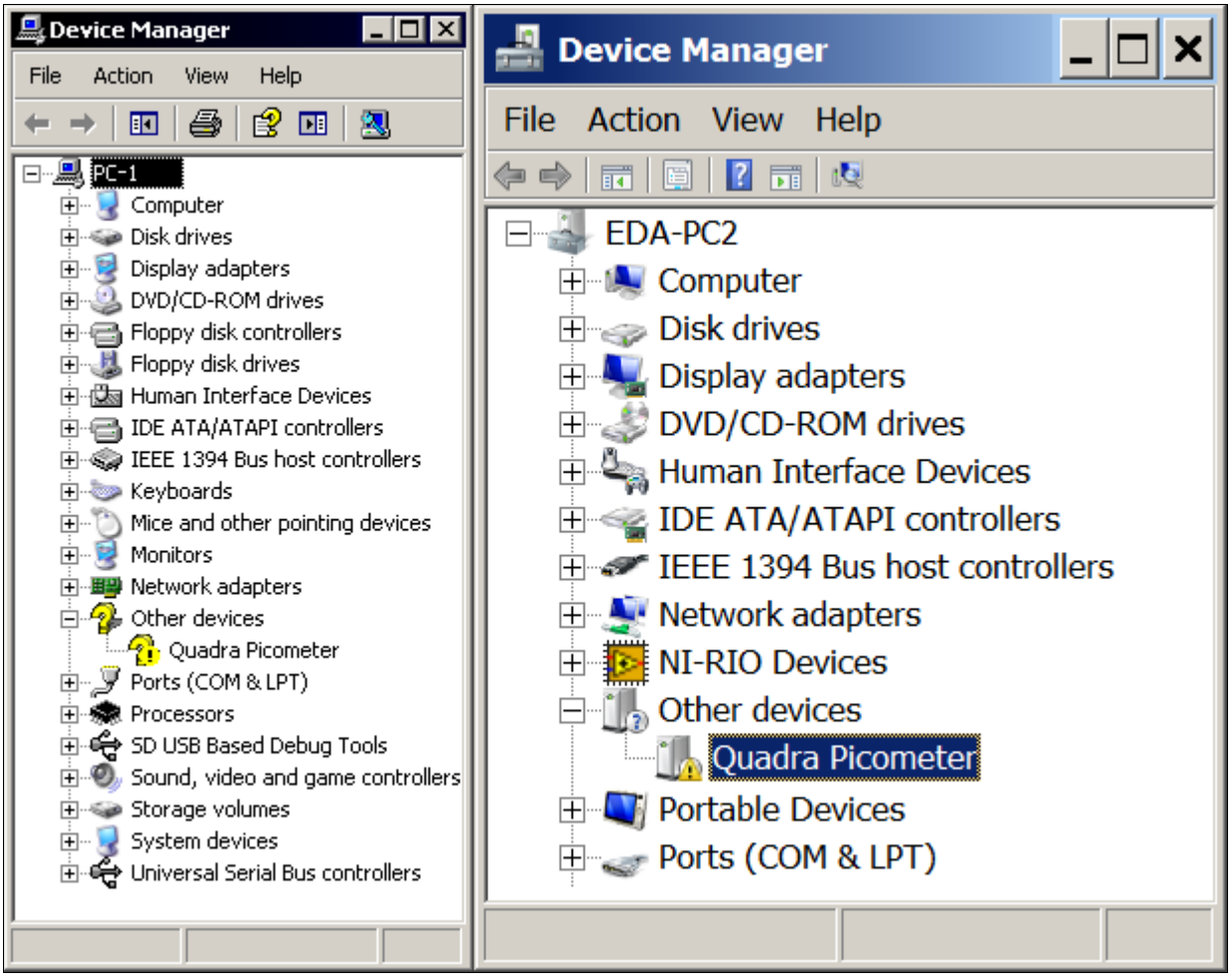

Figure 12 Windows XP and Windows 7 Device Manager

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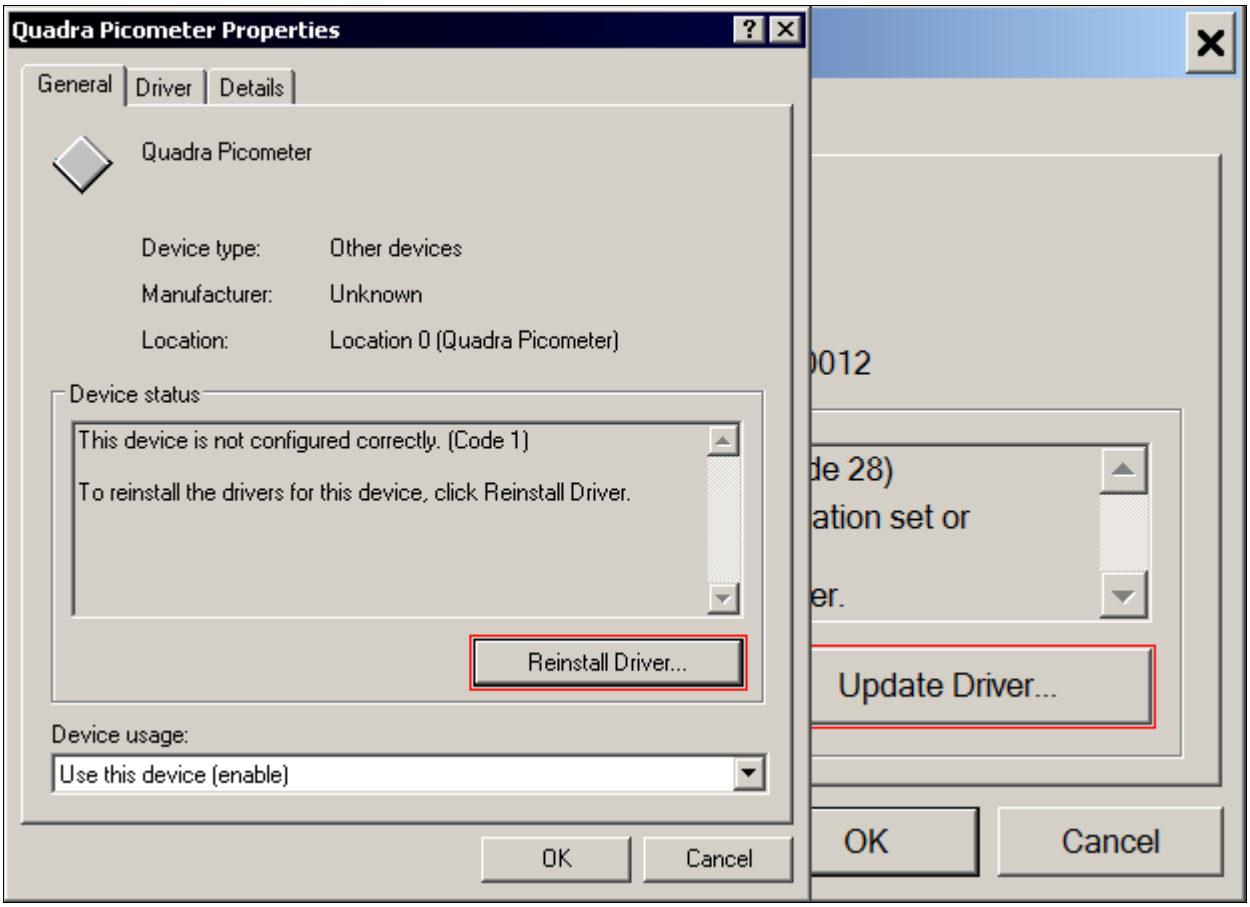

Figure 13 Update Device Driver

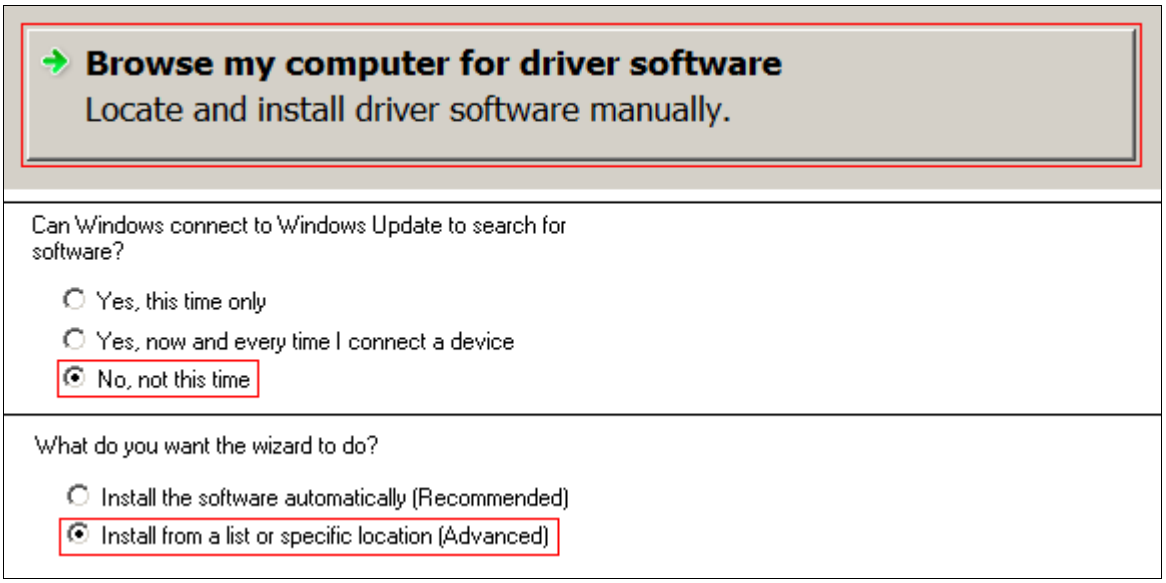

Figure 14 Select Driver Software Source

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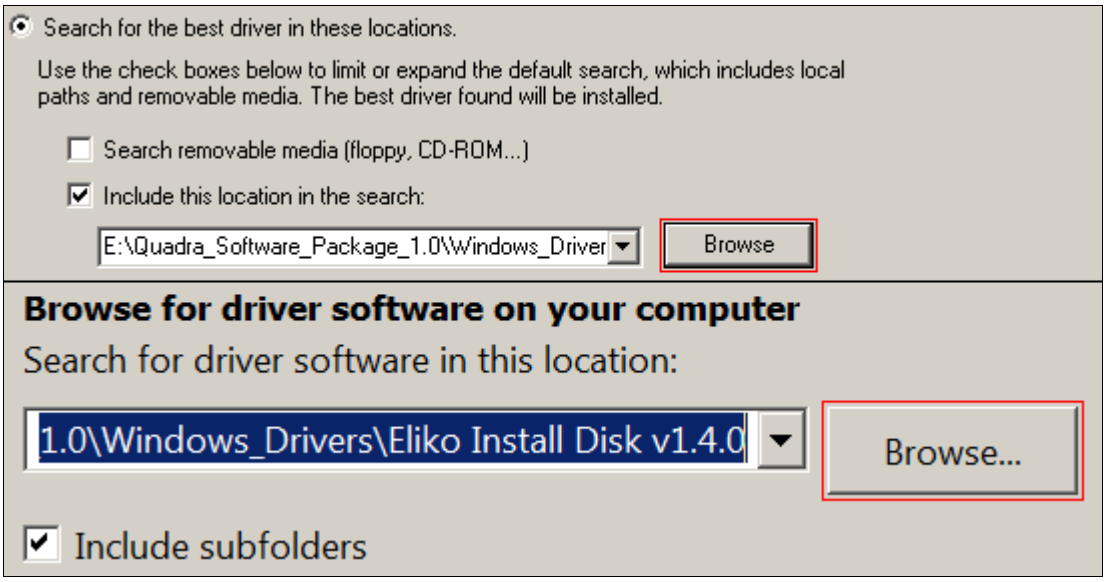

Figure 15 Select Device Drivers Folder

During the installation, Windows may prompt security warning where user must click *Install this driver software anyway* (or *Yes* in Windows XP) to continue with driver install. When Windows has finished installing the drivers then the Quadra device should appear in *Device Manager* as *Quadra Picometer* under category *Eliko Impedance Devices* (**Figure 17**).

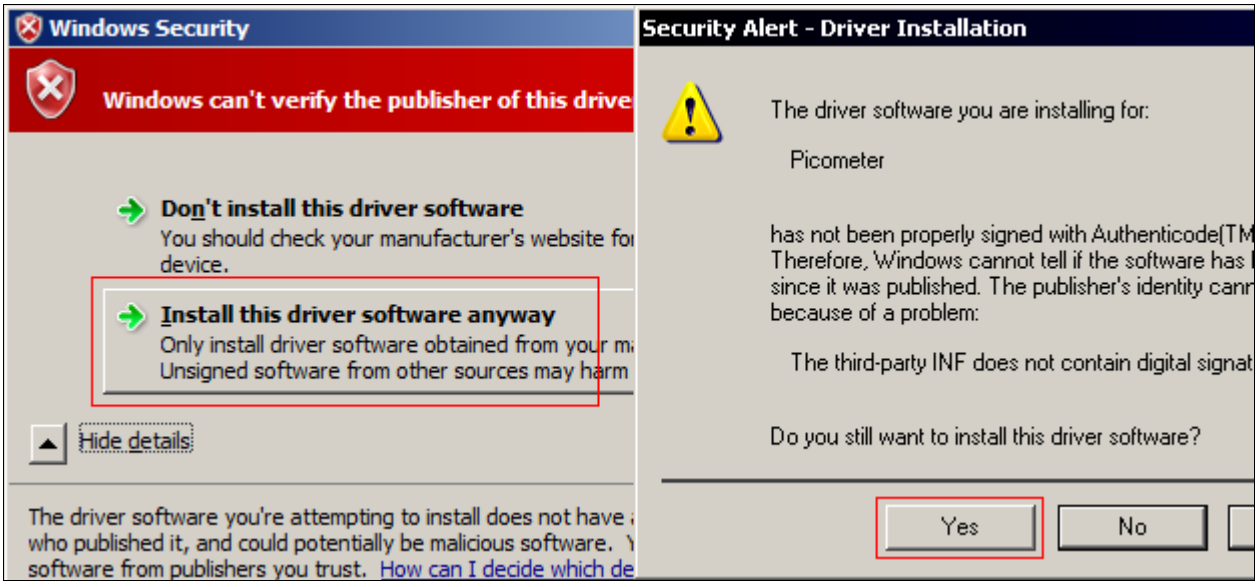

Figure 16 Security Warnings

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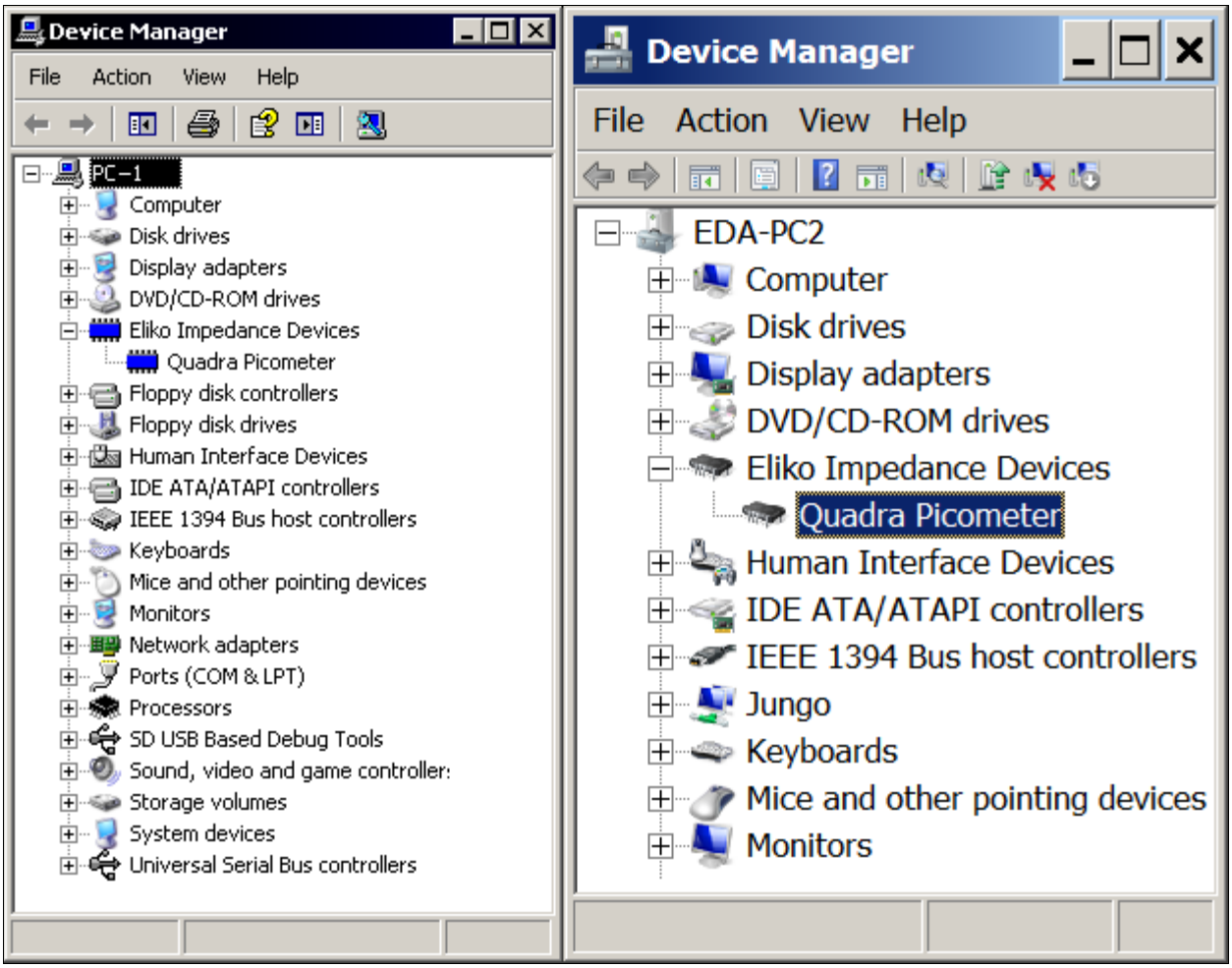

Figure 17 Device Drivers Installed

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Device Connectors

Figure 18 Connectors and indicators on the front and back panel.

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USB Connector

Mini-B type USB connector is located on the front panel. USB connection is used to provide power supply to the device and for charging the internal battery (**Figure 18,** *USB)*. Independently of the power supply modes (internal battery or USB), the USB bus data lines are used to transmit measurement data, receive control commands and configuration data. The USB bus channel speed is 12 Mbps (Full Speed) and the data rate can be up to 1.6 Mbps during active measurement mode. The USB controller on DSP side has a data buffer for storing measurement data for 64 ms. In case a delay longer than 64 ms occurs in data reception by PC host, some loss can be expected. When connected to PC, the device automatically switches to USB bus supply. To switch device to battery supply, follow the steps in p. **Error! Reference source not found.**.

Synchronization Input-Output Connector

Synchronization Input-Output SMA connector *(SYNC-IO* on **Figure 18)** operates by default as output, the SYNC-IO signal is toggled after every 1 ms during active measurement mode. This 1 ms toggle period is synchronous with the excitation signal generation and measurement channel's ADC buffer sampling. Therefore, this SYNC-IO can be used to get synchronization according to impedance spectra acquisition periods. The SYNC-IO can also be configured as input, which enables to switch the device to active measurement mode when the input is set high, similarly to selecting external triggering (p.**Error! Reference source not found.** in section "Using Control Panel Application" of this manual). During the period when input is kept high, the measurement runs continuously, and when the input is set low, the measurement is terminated immediately. Synchronization Input-Output level is 3.3 V and the input is 5 V tolerant.

Analog Front-End Connector

DSUB-25 type connector located on the back panel of Quadra device (**Figure 18, Figure 19**) provides all necessary analog inputs and outputs, supply and digital IO lines that are required to connect and operate an analog front-end. Standardized DSUB allows to connect application specific front-end setups and customize the input of Quarda device for different measurements. The connector pin-out is listed in **Table 3**.

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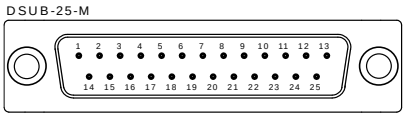

Figure 19 Analog Front-End Connector

Table 3 Analog Front-End Pin-Out

Pin Number	Direction	Function
1	Passive	GND
2	Analog Input	U_P_SENSE
3	Analog Input	U_P_GUARD
4	Analog Input	U_N_GUARD
5	Analog Input	U_N_SENSE
6	Passive	GND
7	Analog Input	I_P_SENSE
8	Analog Input	I_P_GUARD
9	Analog Input	I_N_GUARD
10	Analog Input	I_N_SENSE
11	Passive	GND
12	Analog Output	Excitation Signal Positive
13	Analog Output	Excitation Signal Negative
14	Passive	GND
15	Passive	GND
16	Analog Supply	-5 V, 100 mA
17	Passive	GND
18	Analog Supply	+5 V, 150 mA
19	Digital Input Output	User GPIO 1
20	Digital Input Output	User GPIO 2
21	Digital Input Output	User GPIO 3 (Used for front-end detection)
22	Passive	GND
23	Digital Input Output	I2C Bus Serial Data IO SDA
24	Digital Input Output	I2C Bus Serial Clock IO SCL
25	Digital Supply	+3.3 V, 150 mA

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Device Indicators

On the device front panel are located four LED indicators for different functions (**Figure 18**, *B*, *BSY*, *ERR/ACK*, *RDY*). All four LED's are controlled by DSP software where every LED indicator signals one or multiple events and conditions.

Table 4 LED Indications

LED Indicator	Indication Mode	Description
RDY	On constant green.	DSP is powered and DSP firmware has booted.
	Off.	DSP firmware encountered critical error during normal operation or DSP firmware did not boot.
ERR/ACK	On constant red.	DSP firmware encountered critical error during normal operation. DSP firmware operation is halted.
	On for period of 125 ms.	Acknowledges that received control command execution was successful.
	Toggled twice with periods of 125 ms.	During active measurement DSP USB controller transmit buffer overflow has occurred and 40 ms of data has lost.
	Toggled four times with periods of 125 ms.	Indicates that the last received control command execution failed or the latest data transfer at I2C bus has failed. To get the specific error event the user must send control command (*GET STATUS*) that requests device software version string with device error flags.
BSY	On constant orange.	Indicates that DSP is operating in active measurement mode and some of the time-consuming control command executions are disabled because DSP is busy with data processing.
	Off.	Indicates that DSP is in idle mode.
B	On constant green.	Indicates that battery charging has completed and device is currently running on USB bus power.
	On constant red.	Indicates that device is operating on battery supply.
	On constant orange.	Indicates that battery is charging and device is operating on USB bus supply.
	Red toggling with periods of 400 ms.	Indicates that battery is low and in any moment the device will switch back to USB bus supply.
	Toggling between red and orange with periods of 800 ms.	Indicates fault condition on battery management unit.

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Indoor use only.

Do not dispose, contains battery element.

Read the user manual completely and carefully for proper use.

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