NEXUS™

Operator's Manual

Version 02-2025-012

PalmSens

If you have problems

First make sure to check the "Troubleshooting" section in this document and the Knowledge Base on our website: **www.palmsens.com/knowledgebase/**
This page contains support information on installation, software updates, and training.

Please make sure your software and firmware are up-to-date.

In case of persistent problems:

Use the contact form:	**www.palmsens.com/contact/**
Give us a call:	**+31 30 2459211**
Or send an email:	**info@palmsens.com**

Try to describe the problem as detailed as possible. Sending us the relevant method files, data files and screenshots can be helpful.

Please include your instrument model and serial numbers, as well as any applicable software and firmware version you are using.

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- Loss of data or research results caused by software crashes, hardware failures, or power interruptions.
- Personal injury or property damage resulting from incorrect wiring, exposure to hazardous chemicals, or misuse of electrical connections.

Results obtained using PalmSens instruments depend on experimental conditions, sample properties, and user expertise. Users are responsible for verifying the validity of their data.

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See Appendix A for CE declaration of conformity.

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Nexus Operator’s Manual.

Contents

1 Introduction

1.1 The scope of this manual

This manual covers the handling, characteristics, troubleshooting, and other practical information regarding the hardware specifics of the Nexus, as well as maintenance and compliance.

Please refer to the **Quick Installation Guide** that was supplied with the instrument for instructions on installing the instrument and the software. Additionally, the section **Getting Started** in the digital **PSTrace Manual**, that is installed with the software, provides detailed instructions for conducting first measurements with your instrument.

Initial setup and basic operational instructions for conducting initial measurements are detailed in the "Quick Installation Guide" supplied with the instrument.

The PSTrace Manual is an in-depth document covering not only the PSTrace software but also the hardware limitations for each technique supported by the instrument. It is written to give you a full understanding of both the software and hardware aspects, making sure you're well-equipped to use all the functionalities of the Nexus.

2 About the Nexus

The Nexus is a very compact high-end benchtop potentiostat / galvanostat / ZRA (Zero Resistance Ammeter) and impedance analyzer for use with electrochemical cells. The instrument is a low-noise and low-current potentiostat and galvanostat which controls the potential or current applied to a sample and measures the current or potential response. The Nexus is built using the latest advancements in electronics technology and uses our proprietary MethodSCRIPT™ communications protocol.

The Nexus offers high-end specifications in a small form factor. Specifications include:

- ±1 A range of current control or measurements;
- 1 M samples per second data acquisition;
- iR-compensation;
- Bipotentiostat functionality (optional);
- Dual EIS up to 1 MHz.

Connecting to the Nexus directly is quick and easy via its USB-C port, however for a more robust and remote connection, the built-in ethernet (LAN) port offers a solid alternative. Typical applications for the Nexus include electroanalytical chemistry, energy conversion, corrosion studies and life sciences / (bio)sensors.

2.1 Hardware capabilities

The Nexus circuitry encompasses the hardware for the following aspects:

- Signal generation (DAC and DSP) and signal acquisition (ADC);
- Analog Front-End with different filter settings for optimal signal acquisition;
- Filters and signal conditioning;
- Current-to-voltage converter (TIA);
- Dual-core microcontroller for parsing and running MethodSCRIPTs, hardware control, communication and user interaction;
- Memory for buffering and storing data and parameters;
- Mass storage for data back-up purposes.

2.1.1 Modes

The Nexus can work in two different modes, the potentiostatic (PSTAT) mode and the galvanostatic (GSTAT) mode.

Potentiostatic mode: in this mode, the Nexus regulates the potential at the working-sense electrode relative to the reference electrode. To achieve the desired working potential, the counter electrode is adjusted accordingly, within the constraints of the control amplifier's +12 V compliance limit. The working electrode potential can be controlled over a range of ±10 V.

Galvanostatic mode: in this mode, the Nexus precisely controls the current between the working and counter electrodes, maintaining it at the specified fraction of the selected current range (up to its maximum limit). The counter electrode is adjusted to the necessary potential, within the control amplifier's +12 V compliance limit, to achieve the desired cell current. While the reference electrode is not part of the control loop, it is typically used to monitor the potential at a specific point in the electrochemical cell relative to the working-sense connection.

2.2 Accessories

The Nexus is supplied standard with the following accessories:

- 100-240 VAC to 12 VDC power adapter
- 1 meter cell cable with 2 mm banana plugs, stackable connectors
- 1 m cable for using a second sense
- Crocodile clips for every lead (2 mm)
- Chassis ground cable with croc clip (4 mm)
- USB-C cable
- Ethernet cable
- Dummy cell
- USB stick with software
- Hardware Sync Link cable
- Soft carrying case

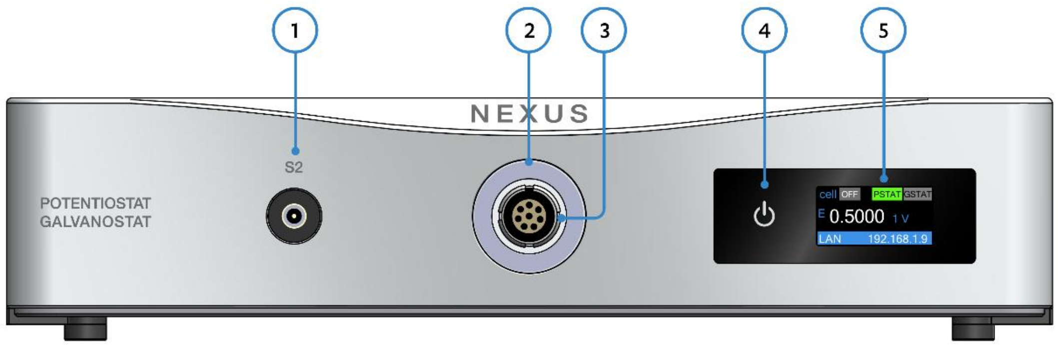


Figure 1 Nexus front side

The front side of the instrument contains the following

1. Second Sense connector (SMB)
2. Cell status indicator ring
3. Cell connector (LEMO)
4. Touch power button
5. Display

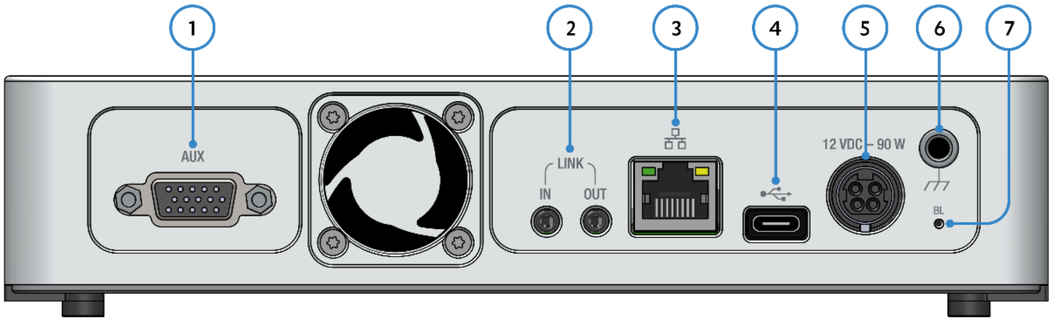


Figure 2 Nexus rear side

The rear side of the Nexus provides the following connectors and button:

1. Auxiliary port (DE-15)
2. Link ports for linking to another Nexus for hardware synchronization
3. Ethernet port for connecting to LAN
4. USB-C port
5. 12 VDC power connector
6. Chassis GND connector
7. Bootloader emergency pin-hole button

2.3 Software

The Nexus is compatible with PSTrace 5.12 or later, PSTrace Xpress 1.6 or later and MultiTrace 4.6 or later.[1]

[1] PSTrace Xpress 1.6 and MultiTrace 4.6 are expected to become available in Q3 2025.

3 Safety considerations

3.1 Inspection

Inspect the instrument for shipping damage when received. In case of doubts, please notify PalmSens BV immediately. A damaged instrument could be a safety hazard. Keep the box the instrument was shipped in case it is required for evidence.

3.2 Electrical safety

The Nexus is powered by an external 12 V power supply. Make sure to always use the power supply that was provided with the instrument. Using an incorrect adapter can result in overheating or damage to the instrument.

3.3 Overheating

The instrument has an air-inlet at the bottom front of the instrument and a fan positioned at the rear of the instrument. Make sure the inlet and the outlet are not obstructed and use the instrument in a well-ventilated area. The enclosure of the instrument should never get any warmer than 50°C. In case the instrument is generating significant heat during operation, make sure to check the fan is working properly and check the inlet for obstructions. The instrument will automatically shut off the cell in case it overheats itself, by monitoring its internal temperature.

3.4 Chassis ground

The Nexus is designed to be a "floating" instrument, which means that its internal circuitry and its enclosure are not connected to earth ground. The instrument ground is also isolated from the USB ground and the 12 V power supply ground.

In case the situation arises where it is required to have the instrument ground tied to earth ground, the supplied Chassis Ground cable can be connected to both the Chassis Ground on the instrument and a source of earth ground. Sources of earth ground include:

- grounded electrical outlets (three-prong outlets);
- (uncoated) metal water pipes;
- or a dedicated grounding post or point.

Most electrochemical cells are not connected to earth ground, making it unnecessary to isolate the Nexus from earth in these cases. In such cases, connecting the Nexus chassis to earth ground may help reduce noise observed during electrochemical tests.

Be aware that connecting an externally grounded instrument to the auxiliary port will annulate the floating capabilities of the Nexus.

3.5 Environmental Conditions

The Nexus is designed for indoor use only. Keep the instrument away from liquids and prevent water vapor condensing within the enclosure. Exposure could lead to corrosion or short-circuiting.

Your Nexus was designed for indoor use at ambient temperatures between 0 °C and 45 °C. The temperature limits for storage are -20 °C and 75 °C with a relative humidity of maximum 90%.

4 Installation

4.1 Preparing for operation

If the Nexus was taken from a cold location into a warm humid location, water vapor might condense at the inside. If this is the case, it is important to leave the instrument in the room for at least an hour before connecting it to the power supply.

Place the Nexus on a flat solid surface to ensure proper airflow to the inlet at the bottom-front. Make sure there's enough space at the rear end for the connection to a USB-C or ethernet cable and the mains power adapter.

4.2 Nexus configurations

The Nexus is available in different configurations. The following table shows which configurations are available. A limited configuration can always be upgraded remotely via software to add functionality. Please contact PalmSens BV, if you are interested in upgrading your Nexus.

Table 1 Nexus hardware configurations available from PalmSens BV

Article code	EIS capable	Bipotentiostat capable
C-NXS.F0	NO	NO
C-NXS.F1	YES	NO
C-NXS.F0.BP	NO	YES
C-NXS.F1.BP	YES	YES

A limited configuration can always be upgraded remotely via software to add functionality.

4.3 Stacking

In case there are multiple Nexus instruments present, they can be stacked on top of each other. The Link ports at the rear can be used to connect them for running hardware-synchronized measurements. These measurements allow for running a measurement with multiple WE's in the same cell. The working electrodes will all be measured parallel, so you could perform four Cyclic Voltammetry measurements (or another electrochemical technique) absolutely synchronized at four different working electrodes in the same solution. Refer to our knowledge base for experimental details.

Each Nexus comes with a Hardware Sync cable. In order to connect the Link ports, make sure to connect the 'Link Out' port of each Nexus to the 'Link In' of the next Nexus in the stack. See also Figure 2 below.

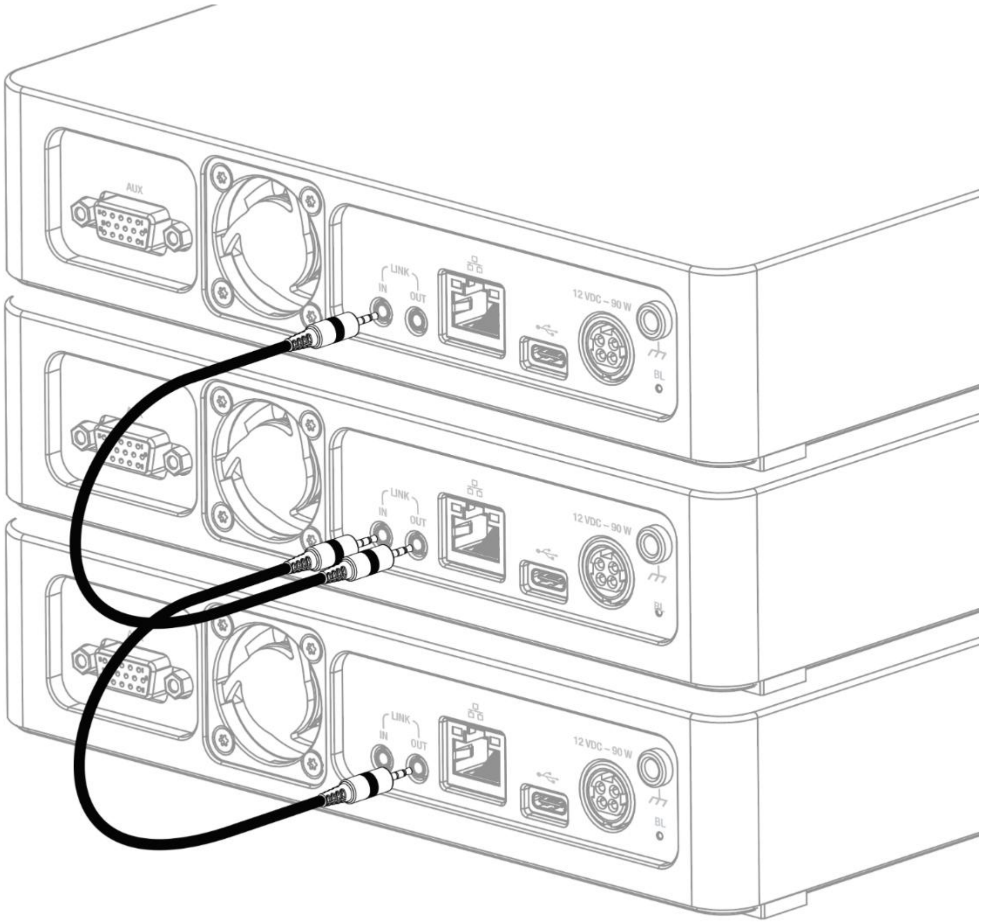


Figure 2 Connecting the 'Link Out' to the 'Link In' of the next Nexus in the stack

The synchronization works with a leader/follower protocol, where the leader or master is always the instrument that has been assigned as first channel in our MultiTrace software. Thus, the stack starts with the leader receiving the first 'Link Out' connection.

5 Operating the Nexus

The Nexus can either be connected via the USB-C port or via the Ethernet port for connecting to a Local Area Network (LAN).

5.1 Powering up

When the Nexus is powered using the supplied power supply, the touch power button on the front will show an amber color, indicating that the instrument is powered on and in standby mode.

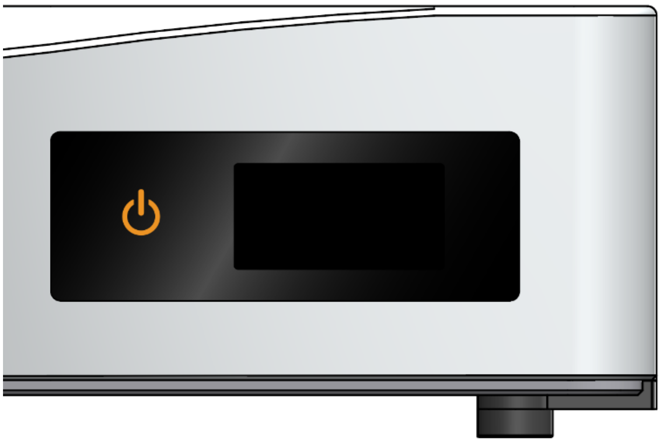


Figure 3 Power button showing an amber color when in standby mode

Touching the power button for a moment will switch on the instrument. If the Nexus is placed in a glove box, a stylus might be required to enable the capacitive touch button.

While starting up, the Cell indicator ring will 'breathe' (slowly fading in and out) in a blue color.

An instrument self-test will be performed at every startup. If an issue is found, an error tone will be played, and the screen will show an error message for 10 seconds before continuing the startup process. The Cell indicator ring will permanently blink at 1 Hz in an amber color as long as the instrument is in an error state.

Possible errors include:

- "Unable to read EEPROM"
- "Invalid calibration data"
- or other errors regarding failed sub-systems.

When the instrument is fully booted and ready for use, it displays a white power icon, shows idle readings on the display, and the Cell indicator ring becomes blue.

For more information regarding the Cell indicator ring, see section **Display and cell indicator** on page 16.

5.2 Connecting via USB

The Nexus has a USB Type-C (USB-C) port and uses the Full-Speed USB 2.0 specification. The Nexus can be used with any common USB port. The instrument comes standard with a shielded USB-C to USB-A (standard rectangular plug) cable.

The required USB drivers are installed automatically when installing the PSTrace or Multitrace software.

The floating (galvanically isolated) characteristics of the Nexus will remain intact, even if the PC it is connected to is grounded to earth.

5.3 Connecting via Ethernet

When the Nexus is connected via its ethernet cable to a Local Area Network or LAN, the DHCP server in the network will assign it with an IP address automatically. This is a unique address which can be used to connect to the Nexus. The address is shown on the display, as soon as the Nexus gets it assigned.

Make sure your PC is in the same network as your Nexus instrument.

Figure 4 The assigned IP address showing in the blue bar on the display

PSTrace allows you to enter the IP address in order to establish a connection. Please refer for more information to the "PSTrace Manual".

5.4 Firmware updates

Firmware updates for the Nexus are distributed through PSTrace updates. In case a new version of PSTrace comes with a new firmware package for the Nexus, the user will be notified upon connecting to the Nexus. The firmware update process is handled automatically by the PSTrace software.

5.5 Cell connections

The Nexus cell cable is a precision-engineered one-meter cable, specifically designed to ensure optimal measurement accuracy with your instrument.

Figure 5 Schematic representation of the Nexus cell cable

The cell cable is connected to the Nexus by means of a LEMO push-pull connector. Make sure the red dot on the connector is facing upwards when plugging the connector into the Nexus.

The Nexus cell connector is a push-pull connector. Do not try to twist / rotate it!

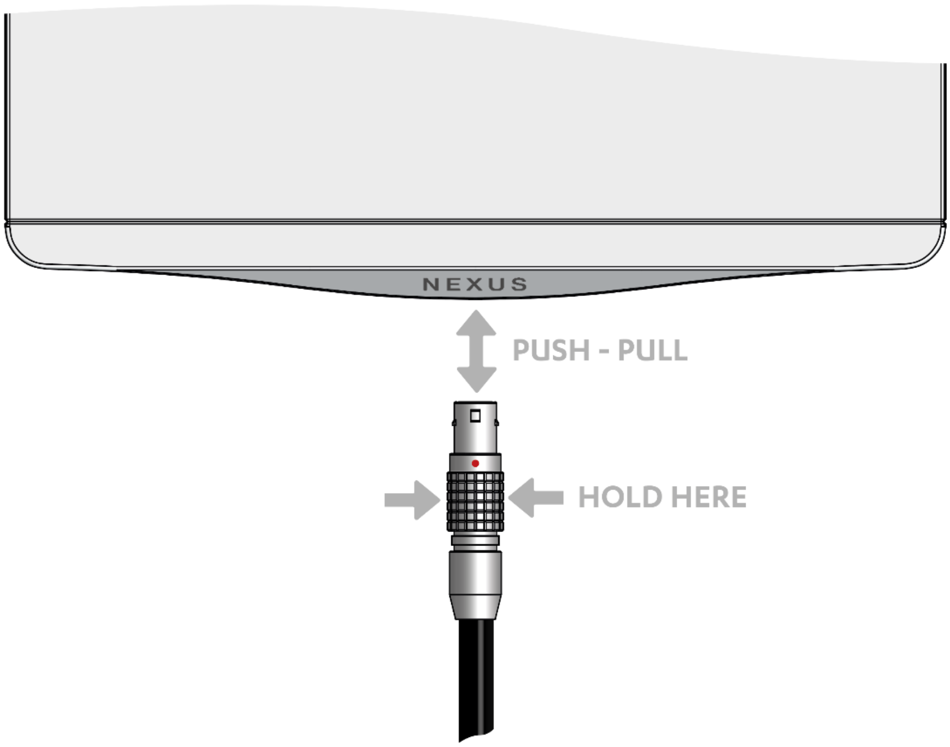


Figure 6 LEMO push-pull cell connector

For more information about making a connection to the cell, see also section: **Connecting a cell to the potentiostat** in the PSTrace Manual.

The following schematics show the Nexus cell cable connector pin-out and pin functions.

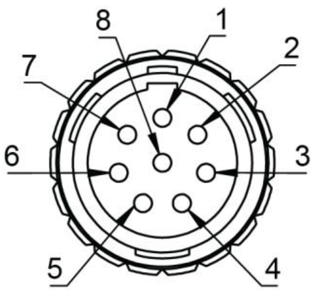


Figure 7 Front view of the male connector of the Nexus cell cable

Table 2 Pin functions and colors of the male connector of the Nexus cell cable

Pin	Function	Connector color
1	Sense Electrode Shield	N/A
2	Sense Electrode (S)	White (stackable)
3	Working Electrode 2 (WE2) (Only present for Nexus with Bipotentiostat capabilities)	Yellow
4	Working Electrode (WE)	Red
5	Counter Electrode (CE)	Black (stackable)
6	Reference Electrode Shield	N/A
7	Reference Electrode	Blue
8	Working Electrode Shield	N/A
Connector housing	Analog Ground (AGND)	Green

5.5.1 Second Sense (S2)

The S2 connector can be used to monitor a potential vs RE or versus S or used to measure the half-cell potential during a dual-EIS measurement.

Figure 8 The Second Sense (SMB) connector is found at the Nexus front side

The second sense connects to the S2 port at the front which is a standard coaxial push-pull SMB connector. The 2 mm banana connector at the cell-end of the cable can be stacked in between the cell and the counter electrode.

5.6 Display and cell indicator

The Nexus has a color display and illuminated indicator ring around the cell connector to indicate the cell status.

The following picture shows typical contents for the display when the instrument is idle. In the idle mode, the Nexus will update the display with the measured potential or current at one second intervals. In case the Cell is set to OFF, the open-circuit potential is measured and displayed. In case the Cell is ON, either the i or E is displayed, depending on the selected PSTAT or GSTAT mode.

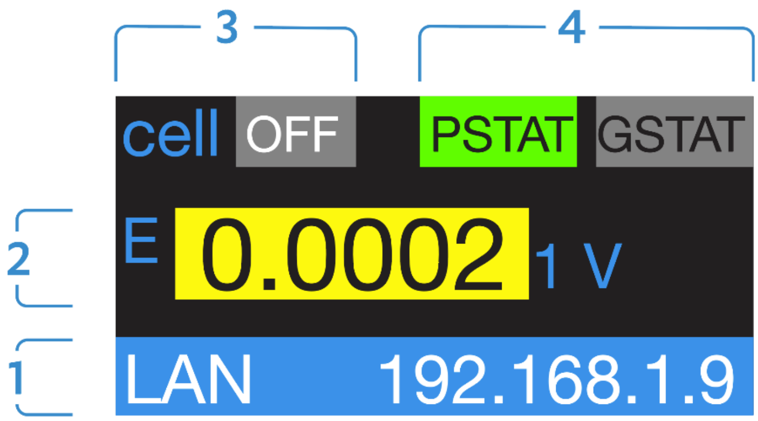


Figure 9 Nexus display when in idle mode

The display is divided into the following elements:

1. The blue bar at the bottom shows the connection status, which can be "USB" or "LAN" or empty. In case the instrument is connected to a LAN, it will show the IP address it was assigned.

2. Area showing the readings when the instrument is idle (not running a MethodSCRIPT / measurement).

   The first part is either an E or an i, depending on the mode setting PSTAT (potentiostatic) or GSTAT (galvanostatic) and the cell state. Next to the E or i, the measured value and the range the value was measured in are shown.
   In case the value was measured in an *underload* state, the background of the value will be yellow. An underload means that a lower range could be used to improve the measurement resolution. See also section **Potential and Current ranges** in the PSTrace Manual.

   In case the measured value is measured in the optimal range it will show white with a black background.

   In case the measured value is out of the selected range it will be in *overload* status which is shown with a red background.

3. The cell state is shown here. This can either be ON (with a red background) or OFF (gray background). In case the cell is OFF the open-circuit potential is displayed.

4. The area showing the mode the instrument is in. The instrument can either be set in PSTAT mode where it controls the potential or in GSTAT mode, where it controls the current.

The illuminated indicator ring is used to communicate the device state. The following table shows the meaning of the different states the indicator ring can have.

Table 3 Meaning of the different states of the illuminated indicator ring around the cell connector

State	Pattern
Starting up or shutting down	Breathing blue at 0.5 Hz
Cell off	Solid blue
Cell on	Breathing red at 1 Hz
MethodSCRIPT paused	Rotating white at 0.33 Hz
Warning	Blinking amber at 2.5 Hz
Error	3 short red flashes every second

Additionally, the illuminated indicator ring behavior can be controlled from MethodSCRIPT using the “notify_led” command. The following table shows the different supported notify modes.

Table 4 Meaning of the different Notify modes of the illuminated indicator ring around the cell connector

Notify mode	Pattern
Idle	Solid blue
Busy	Solid red
Notice	Blinking white at 1 Hz
Pass	Blinking green at 1 Hz
Fail	Blinking red at 1 Hz
Warning	Blinking yellow at 1 Hz
Error	Blinking yellow at 2 Hz

See the MethodSCRIPT documentation found on our website for more information: **www.palmsens.com/methodscript**

5.7 iR Compensation

IR (ohmic drop) Compensation in the Nexus operates through Positive Feedback. This is achieved using a 16-bit MDAC in the module which scales the output of the current follower to provide a positive feedback voltage that is proportional to the current through the cell. The compensation voltage is added to the summing point before the control amplifier and thus increases (or decreases) the applied potential to counteract the ohmic drop.

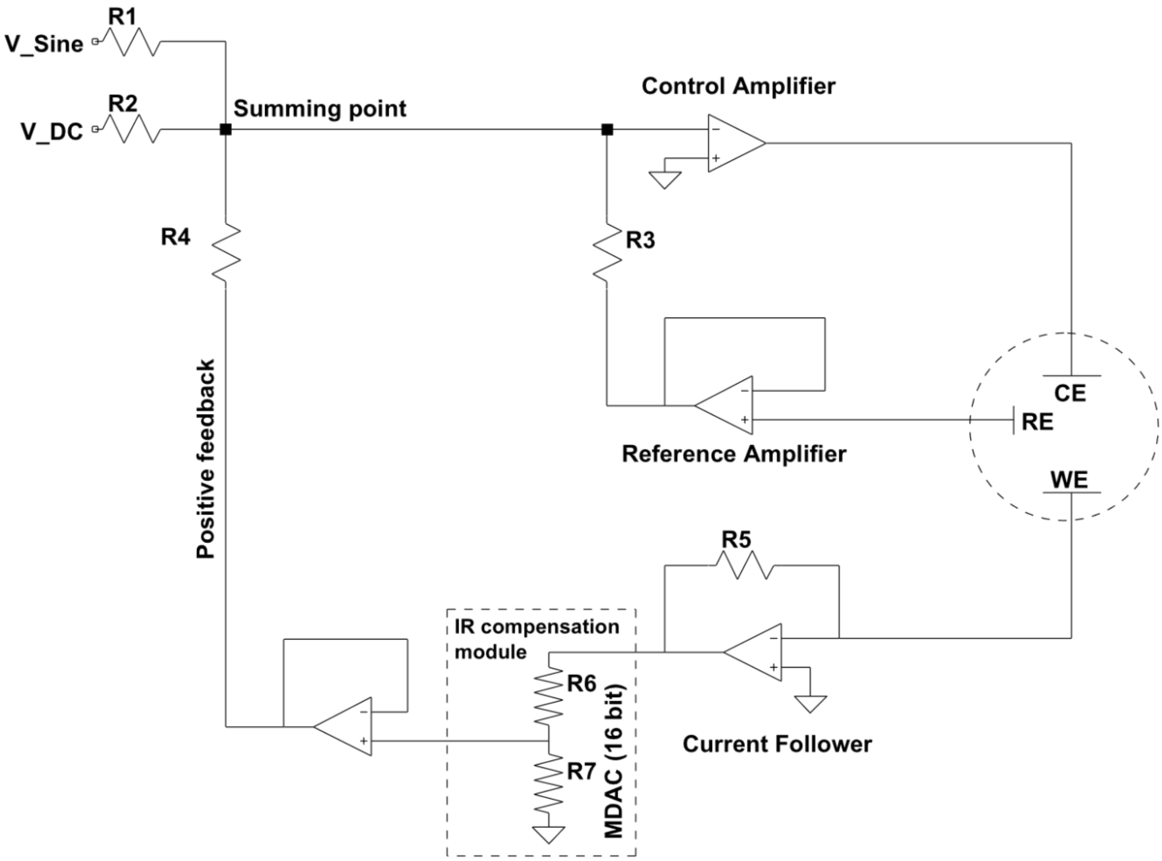


Figure 6 Simplified schematic representation of iR compensation circuitry in the Nexus

Positive feedback allows for fast scan rates up to 10 V/s, depending on the characteristics of the cell. If the potential error to compensate for becomes close to the value set for E applied, the system might become unstable. Using iR compensation limits the measurement bandwidth to 10 kHz and requires the selection of a (manual) single current range.

See also section: **Ohmic (iR) compensation** in the PSTrace Manual, and the application note in the Knowledge base of our website: **iR Compensation and Uncompensated Resistance**.

5.8 Bipotentiostat

The Nexus, depending on the configuration chosen, can also function as a Bipotentiostat, which is a potentiostat with two working electrodes. If the second Working Electrode (yellow W2 lead) is not being used, it can simply be left unplugged. Attach the provided croc clip to avoid accidental electrical contact.

A Bipotentiostat can use two working electrodes, one reference and one counter in the same cell. The two working electrodes can be operated and monitored exactly at the same time.

Working electrode one (W1) performs any of the supported techniques (see section further below), while working electrode two (W2) can either have its own constant potential or follow the working electrode one's potential. In the latter case a potential offset can be added.

5.8.1 Bipotentiostat application examples

- Second electrode as a blank or similar in the same cell for comparison
- Detecting the product of a disc electrode's reaction at its ring of a RRDE (Rotating Ring Disc Electrode)
- Polarize the surface during scanning electrochemical microscopy (SECM)
- Controlling gate voltage and source-drain voltage of an Ion selective field effect transistors (ISFET)

5.8.2 Supported techniques for use with Bipotentiostat

The following techniques are supported for the Nexus bipotentiostat:

- Linear Sweep Voltammetry
- Cyclic Voltammetry
- Amperometric Detection
- Multistep Amperometry

Please refer to section **Using a BiPot** in the PSTrace Manual, for more information.

5.9 Using the Nexus as ZRA

The Nexus can also be used as a Zero-resistance Ammeter (ZRA). A Zero-Resistance Ammeter is a specialized mode used in potentiostats, primarily for measuring current between two electrodes while maintaining zero voltage (potential) difference between them. The ZRA mode ensures that no significant potential is applied between two electrodes, while the current flow between them is accurately measured.

While keeping the potential difference near zero, the potentiostat measures the current flowing between two electrodes. This current is the main variable of interest in ZRA mode, providing valuable insights into processes such as corrosion, galvanic coupling, and other electrochemical phenomena where a potential difference is not deliberately applied but current is exchanged.

If a potentiostat is used as a ZRA, in most setups it needs to be floating (Galvanically Isolated). The reference electrode (blue) and counter electrode (black) connections of the potentiostat need to be stacked and left disconnected to anything else. See the following image for a schematic representation.

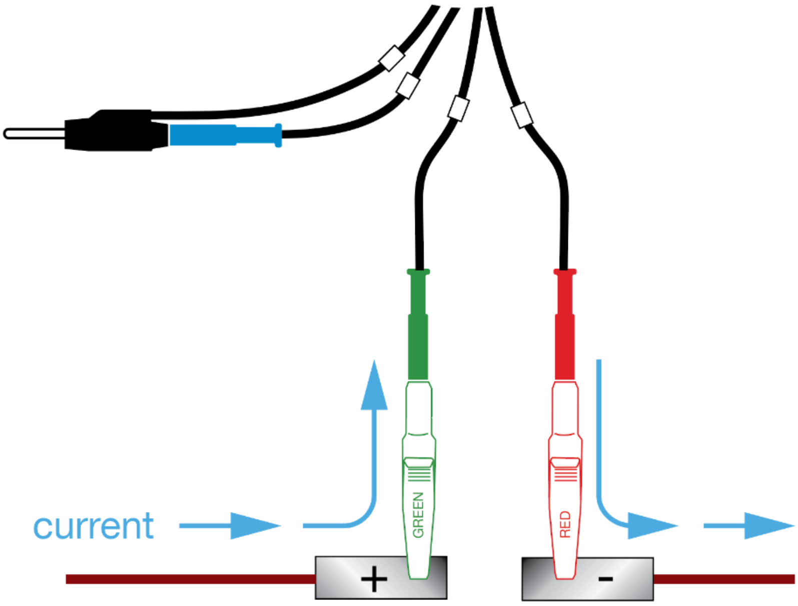


Figure 10 Connecting the Nexus cell cable for ZRA measurements

The current flows through the working electrode lead (red) and the ground lead (green). The Working Electrode is connected to the input of the current follower and the + input is connected to Ground. The voltage difference between the Working Electrode and ground is zero and the current will be measured.

ZRA can only be used with the non-shunt CR's starting at 100uA and lower.

Use the technique Chronoamperometry in software to record the currents. The applied potential setting can be ignored.

5.10 Auxiliary port pin-out

The following schematic and table show the Nexus auxiliary port pin-out and pin functions.

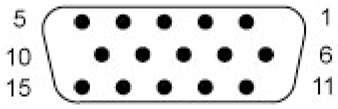


Figure 11 The front view of the female port (DE-15) on the Nexus

Table 5 Nexus auxiliary port pin functions

Pin	Function
1	GPIO 1 = d0 digital output (3.3 V) *
2	GPIO 4 = d3 digital output (3.3 V) *
3	auxiliary analog input -10 to +10 V, 18 bit, >0.5 MOhm input impedance
4	I2C SCL
5	I2C SDA
6	GPIO 2 = d1 digital output (3.3 V) *
7	GPIO 5 = d0 digital input (3.3 V) *
8	i monitor given as V in active current range. (-10 to +10 V Current follower ranges (1nA to 10mA) (-10 to +10 V Shunt ranges (1mA to 100mA) (-2 to +2 V Shunt range (1 A)
9	5V digital power line (max. 300mA)
10	digital ground
11	GPIO 3 = d2 digital output (3.3 V) *
12	GPIO 6 = d4 digital input / output (3.3 V) * configurable through MethodSCRIPT Pulled up to +3V# via 4k99 for Onewire temp sensor.
13	E monitor (-13 to +13 V)
14	analog ground
15	auxiliary analog out (0 to 10 V at 16 bit)
Connector housing	digital ground

> ⚠ Applying external power to pins on the AUX port when the Nexus is switched off can potentially damage the instrument.

5.11 Chassis ground

The Nexus is designed to be a “floating” instrument, which means that its internal circuitry and its enclosure are not connected to earth ground. See section **Grounding** on page 38 for more information. A chassis ground cable with a 4 mm plug and crocodile clip is provided with the Nexus to make an easy connection to a ground point.

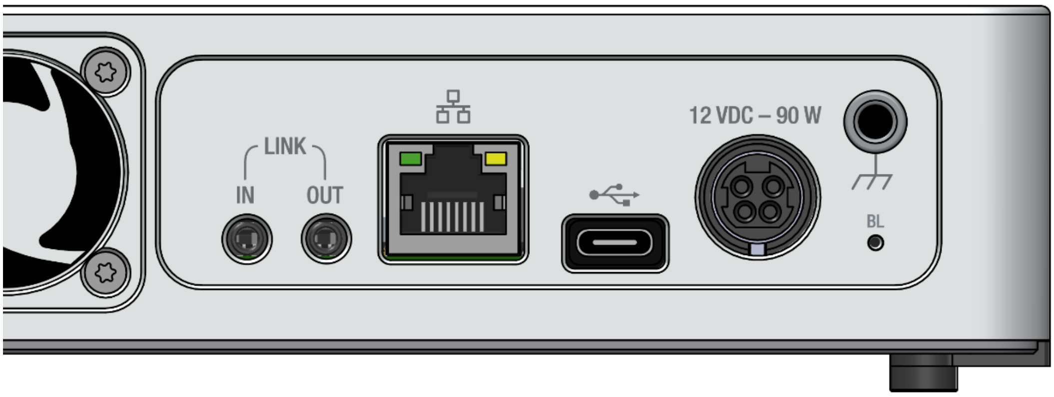


Figure 12 Chassis ground connector showing in the upper right corner (⏚) and the emergency pinhole (BL) at the bottom right corner

5.12 Bootloader emergency pinhole

If the Nexus firmware does not start correctly, it will be impossible to remotely enter the bootloader to upload new firmware. In this case, a thin rod (for example, a paperclip or toothpick) can be inserted in the bootloader emergency pinhole during power up. (See Figure 12.) This will start the Nexus in bootloader mode, so that new firmware can be uploaded using PSTrace.

6 Measurements

The PSTrace software for Windows allows to run all the techniques supported by the connected Nexus. This section explains how to set up a typical measurement. The options and limitations for each technique are described in the PSTrace Manual.

More theoretical background information about electrochemical techniques can be found in:

- Christopher M.A. Brett and Ana Maria Oliveira Brett, Electroanalysis (Oxford Chemistry Printers, 64) Oxford Science Publications, ISBN-13: 978-0198548164
- Joseph Wang, Analytical Electrochemistry 3rd ed, John Wiley & Sons, ISBN-13 978-0471678793

6.1 Connecting a cell to the potentiostat

PalmSens potentiostats are delivered with a cell cable terminated with 2-mm banana plugs as the lead connectors for the cell / electrodes / sample (excluding some models that come with SPE connectors). Each lead is accompanied by a crocodile (alligator) clip of the same color.

We advise keeping an unused lead connected with its crocodile clip. This practice prevents accidental electrical contacts with the exposed banana plug, minimizing the risk of unintended electrical contacts.

See the Table 2 for Nexus standard cable lead colors.

Each electrode cable is individually shielded, and the entire cable features an external shielding mesh. The shielding extends up to the beginning of the banana plug. When you are using a Faraday cage, it is advisable to keep the entire banana plugs inside the Faraday cage housing to ensure the cage shields the banana plug.

6.1.1 2-electrode cell connection

For a 2-electrode setup, combine the counter and reference electrode leads. The counter electrode plug of the Nexus cable is stackable, allowing for convenient combination. Subsequently, connect the combined Sense lead with the working electrode lead to one electrode and the combined counter and reference electrode leads to the other.

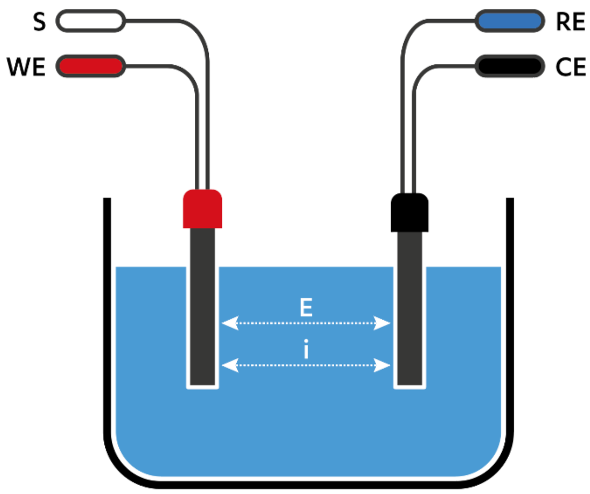


Figure 13 2-electrode cell connection

During a measurement in a 2-electrode setup, the potential will be applied between the two electrodes and the current will flow between the same two electrodes. This means the applied potential includes the potential drop across the working electrode's interface, the potential drop across the solution, and the potential drop across the counter electrode's interface. Any changes at the counter electrode will influence the result. If your counter electrode is expected to be stable during the measurement due to low currents or a short duration of the measurement, you can use this setup almost equivalent to a 3-electrode setup. Otherwise, this setup is only used for applications where the full cell potential is an interesting parameter, for example, fuel cells, batteries, capacitors, dummy cells or electronic components.

Please avoid connecting a self-powered sample, such as batteries, fuel cells or supercapacitors, to an unpowered potentiostat, as this action can potentially damage the equipment. It is advisable to disconnect the sample before turning off the potentiostat to mitigate any risk of damage to the device.

6.1.2 3-electrode cell connection

The 3-electrode setup is the most common configuration for electrochemical measurements. In this arrangement, connect the corresponding leads to the respective electrodes. Combine the sense lead with the working electrode. The sense plug of the Nexus cables is stackable, allowing for convenient combination.

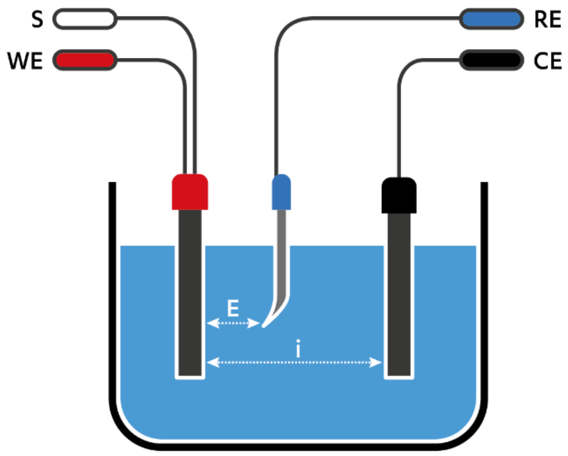


Figure 14 3-electrodes cell connection

Similar to the 2-electrode setup, the working electrode (and sense) carries the current and potential. In this setup, the counter electrode also carries the current and polarizes versus the working electrode (WE). However, the potential is measured between the sense and reference electrodes, denoted as WE(+S) vs. RE. This potential is the one set and read in the plot results.

The potential WE vs. CE is referred to as the 'cell potential,' and it is recorded in special cases.

In potential-controlled experiments, the potentiostat maintains a loop to ensure that the potential read (WE+S vs. RE) remains as programmed in the setup, consistently driving this potential towards the WE vs. CE polarization.

This has the advantage that the potential drop across the counter electrodes interface is compensated. Another advantage is that the reference electrode does not carry any current and will thus keep a stable potential during the measurement. This means the potential of the working electrode is more accurate and reproducible.

4-electrode cell connection

In this configuration, you simply need to connect the corresponding leads to the electrodes, and no plug/lead combinations are required.

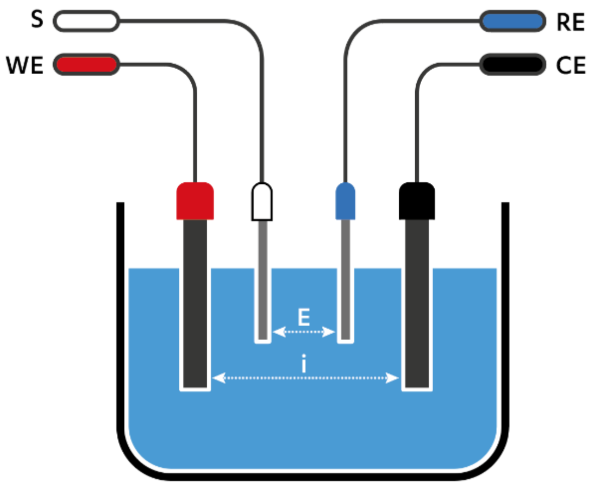


Figure 15 4-electrodes cell connections

The potential is measured between the sense lead and the reference electrode, while polarization drives the current flow between the working electrode and the counter electrode. This arrangement ensures that the potential drops across the counter or working electrodes' interfaces, and the associated reactions, do not contribute to the measurement. Processes specifically across the solution and obstacles, such as a membrane, between the sense and reference electrode, become the primary contributors to the measurement.

This setup is rarely used, with some examples including research solid-state electrolytes, membranes, or liquid-liquid interfaces.

Kelvin Connection

In addition to traditional 4-electrode cell connections, the "Kelvin Connection" serves as a specialized version of a 4-electrode setup, while functionally operating as a 2-electrode configuration. Notably, the sample is still a 2-electrode cell, typically with a very low impedance (high conductivity).

In the Kelvin Connection, like the 2-electrode connection, the CE lead is connected on the same side as the RE lead, while the WE lead is connected on the opposite side of the sample, alongside the sense lead. The key distinction lies in its application when potential drops across cables and connectors must be meticulously considered. The primary objective of the Kelvin connection is to position the RE and sense as close as possible to the sample. This proximity ensures that the impedance introduced by cables and connectors is effectively compensated through the functioning of the potentiostat.

> **Please avoid connecting a self-powered sample, such as batteries, fuel cells or supercapacitors, to an unpowered potentiostat, as this action can potentially damage the equipment. It is advisable to disconnect the sample before turning off the potentiostat to mitigate any risk of damage to the instrument.**

6.2 Low-current measurements

The Nexus potentiostat offers a wide current measurement range, spanning from 100 pA to 1 A. This is achieved by using two different methods of current measurement:

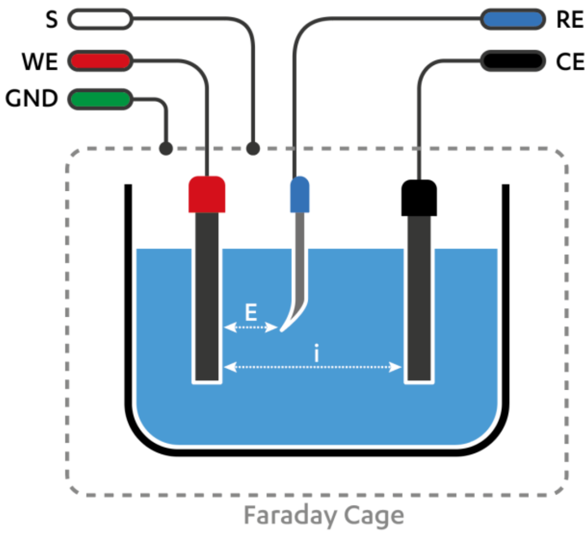
- Transimpedance Amplifier (TIA): current follower used for ranges from 100 pA to 100 µA.
- Shunt resistor: used for current ranges from 1 mA to 1 A.

Due to the high sensitivity required for low-current measurements, the Sense lead can sometimes act as an antenna for external noise, due to the nature of the TIA current follower method. This effect is typically negligible but may become significant when working with very low currents and/or high-impedance samples. Since the threshold for noticeable noise depends on the experimental environment and sample connections, there is no universal cut-off value for when noise becomes problematic.

If you observe excessive noise in your low-current measurements, first perform a test with a dummy cell to determine whether the noise originates from the environment or from instabilities in the sample itself. Refer to the PSTrace manual section "**Measuring the noise level of the instrument**" for detailed instructions on assessing the noise profile. Finally, if you are sure that you are facing excessive environmental noise, consider the following mitigation strategies:

1: Alternative Sense lead connection:

Instead of the conventional setup (where the Sense lead is connected with the Working Electrode lead), connect it to the Ground lead or to any electrical contact point of a potentiostat-grounded Faraday cage. This arrangement is possible because the Working Electrode potential is kept at the same level as the virtual ground. This can help to eliminate unwanted antenna effects.



2. Grounding the instrument:

The Nexus is a floating potentiostat, allowing flexible integration with grounded samples or other systems (e.g., polypotentiostat setups, microbalance systems). However, if the floating capability is not needed, grounding the device can enhance its resistance to external noise. To do this, connect the chassis ground (rear plug) to earth ground, effectively converting the Nexus into a grounded device and improving shielding against external interference. See also section **Grounding**.

By implementing these adjustments, you can optimize the Nexus for precise low-current measurements while minimizing the impact of environmental noise.

7 System Specifications

General	
▪ dc potential range	±10 V
▪ compliance voltage	±12 V
▪ maximum current	±1.1 A

Potentiostat (controlled potential mode)	
▪ applied dc-potential resolution	78 µV
▪ applied potential accuracy	≤ 0.1% or ±1 mV offset
▪ current ranges	100 pA to 1 A (11 ranges)
▪ measured current accuracy	< 0.1% of measured value ±10 pA (bias)
▪ measured current resolution	0.0038% of current range (3.8 fA on 100 pA range)

Galvanostat (controlled current mode)	
▪ current ranges	1 nA to 1 A (10 ranges)
▪ applied dc-current	±5 * range (< 10 mA) ±4.5 * range (10 mA) ±1 * range (1 A)
▪ applied dc-current resolution	0.0038% of applied range
▪ applied dc-current accuracy	< 0.1% of current ±10 pA (bias), ±0.1% of range (offset)
▪ potential ranges	10 mV, 100 mV, 1 V
▪ measured dc-potential resolution	78 µV at ±10 V (1 V range) 7.8 µV at ±1 V (100 mV range) 0.78 µV at ±0.1 V (10 mV range) 78 nV at ±0.01 V (1 mV range)
▪ measured dc-potential accuracy	≤ 0.05% or ±1 mV (for $\lvert E \rvert < \pm 9$ V) ≤ 0.2% (for $\lvert E \rvert \geq \pm 9$ V)

Optional: EIS (impedance measurements)	
▪ frequency range	10 µHz to 1 MHz
▪ ac-amplitude range	1 mV to 0.3 V rms, or 0.8 V p-p

Optional: GEIS (galvanostatic impedance measurements)	
▪ frequency range	10 µHz to 1 MHz
▪ ac-amplitude range	0.001 * range to 0.15 * range RMS (full range) 0.001 * range to 0.74 * range RMS for frequencies up to 1 kHz

Electrometer	
▪ electrometer amplifier input	> 10 TΩ // 10 pF
▪ bandwidth	1 MHz

Optional: Bipotentiostat	
▪ dc-potential range	±5 V
▪ dc-potential resolution	153 µV (16-bit)
▪ dc-offset error	≤ 0.1%, ±1 mV offset
▪ accuracy	≤ 0.1%
▪ current ranges	100 pA to 10 mA (9 ranges)
▪ maximum measured current	i(WE1) + i(WE2) < 45 mA
▪ current resolution	0.0038% of current range
▪ current accuracy	≤ 0.1% current, ±0.1% range (offset)

iR Compensation module	
▪ method used for iR-drop compensation	Positive Feedback
▪ resolution of MDAC used for correcting potential	16-bit
▪ max. compensated resistance	1 MOhm
▪ max. bandwidth with iR-drop compensation enabled	10 kHz

Other	
▪ **electrode connections**	2 mm banana pins for RE, WE, WE2, CE and GND Sense 2 (for monitoring potential at CE or half-cell)
▪ **housing**	aluminium body: 20 x 21 x 4.5 cm
▪ **weight**	1.8 kg
▪ **temperature range**	0 °C to +45 °C
▪ **power**	12V DC external power supply
▪ **communication**	ethernet and USB-C
▪ **internal storage space**	32 GB (or >800 million datapoints)

Auxiliary port (D-Sub 15)	
▪ **analog input**	±10 V, 18-bit
▪ **analog output**	±10 V, 12-bit (1 kOhm output impedance)
▪ **digital I/O**	4x digital output (5 V) 1x digital input (5 V)
▪ **i-out and E-out**	raw output of current and potential E-out ±10 V (2.5 kOhm output impedance) i-out ±2 V (2.5 kOhm output impedance)
▪ **power**	5 V-output (max. 150 mA)

8 Maintenance and compliance

8.1 Temperature compliance

Our instruments are designed for indoor use at ambient temperatures between 0 °C and 45 °C. All the components of PalmSens products (except their batteries) are rated to the industrial temperature standard of -40 °C to +85 °C.

8.2 Humidity compliance

PalmSens instruments have not been tested in high humidity environments.

Elevated humidity however may cause measurement errors if condensation forms on the electronics. This affects measurements in the nA ranges or lower. Prolonged exposure to a condensing environment may severely decrease the life expectancy of the instrument and void its warranty.

8.3 Temperature drift

PalmSens instruments are calibrated at 21 °C. The most sensitive components of the instrument have temperature drift of 50 ppm. For instance at 1 °C or 41 °C, measurement drift of up to 0.1% may be experienced.

8.4 Atmospheric pressure

PalmSens instruments are not intended for use in safety-critical applications. Consequently, the power supplies utilized are not selected based on a specific pressure rating.

8.5 Cleaning

Make sure to disconnect your instrument from any cell or power source, if applicable, prior to cleaning. Use a cloth lightly dampened with either clean water or water containing a mild detergent to clean the outside of the instrument. Alternatively, you can use isopropyl alcohol. Avoid using a wet rag and prevent any fluids from entering the instrument. It is crucial not to immerse the instrument in any cleaning solution.

8.6 Periodic calibration and preventive maintenance

PalmSens instruments are designed in a way that eliminates the need for periodic calibration. While not mandatory, PalmSens does provide a calibration service for users with specific demands such as QC/ISO purposes. This service includes a new calibration certificate.

It's important to note that PalmSens instruments do not require preventive maintenance, further simplifying their use and reducing the overall maintenance demands on users.

8.7 Service and repair

Except for the battery in some models, your PalmSens instrument contains no user-serviceable parts internally. Any service or maintenance needs should be directed to a qualified service technician employed by PalmSens BV. Attempting to access or modify internal components without proper expertise may result in additional damage to the instrument and void warranties. It is recommended to rely on authorized service personnel for any required maintenance or repairs.

8.8 RoHS Compliance

All instruments from PalmSens have been built using lead free components and lead-free solder. They are in compliance with the European RoHS initiative.

9 Troubleshooting

9.1 Verifying your potentiostat

Your instrument can be tested by using the test sensor or dummy cell supplied with the instrument.

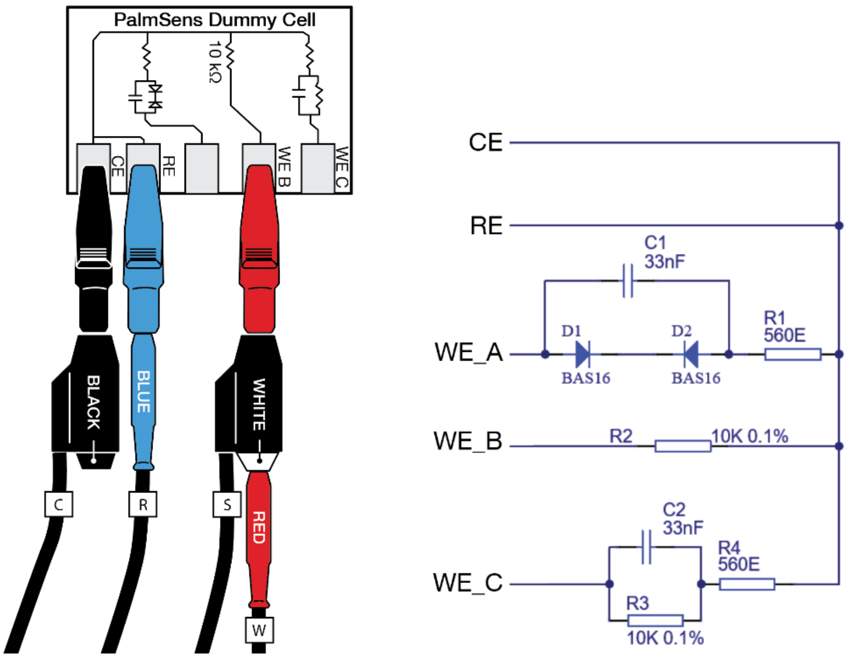


Figure 16 PalmSens Dummy Cell

The easiest way to verify the functioning of your instrument is to use the "WE B" circuit, which consists of a resistor with a value of 10 kΩ with a max deviation of 0.1%.

The WE lead is connected to one side and both RE and CE to the other side of the resistor. Make sure to connect the sense lead to the WE lead as well.

Make sure to stack the sense lead with the WE lead when connecting it to the dummy cell.

Any of the electrochemical techniques can be applied. The current response obtained with a resistor with value R is equal to the applied potential or potential pulse divided by the value of R. So, if a potential of 0.5 V is applied on a resistor of 10 kΩ, the obtained current should be 0.5 V / 10 kΩ = 50 µA.

Contact PalmSens BV if the problems are found: **info@palmsens.com** and report the problems as detailed as possible.

9.2 Noise

Our instruments are designed with hardware noise suppression filters to reject noise from internal and external sources. If a higher level of noise is your issue, the solving strategies are rather numerous, but the sources for noise are also numerous. Here we describe the most successful and common methods for noise reduction.

To determine the noise levels for your instrument, please refer to section **Measuring the noise level of the instrument** in the PSTrace Manual.

9.2.1 Power grid

Your power grid is usually using an alternating current. This undulating current influences the measured currents. PSTrace and PStouch have a filter for this mains frequency. In PSTrace, check in the 'Tools' menu under 'General Settings' if the mains frequency is set correctly (50 Hz or 60 Hz).

9.2.2 Electrical fields

Our environment is filled with electrical fields. Some of them are created by devices around us as side effects or in case of wireless communication on purpose. Although it is a bad idea to measure directly next to an electric arc furnace, it is usually not possible to have a workspace free of electrical fields, especially not during point-of-care measurements. A Faraday cage is usually sufficient to create a field-free environment. A metal box or cage out of metal mesh is a good Faraday cage. Even a shield out of aluminum foil can help. Place your electrochemical cell inside the Faraday cage and connect the cage to the ground lead (green) of the potentiostat. The cable delivered with your instrument has an inbuilt shield and should protect your signal outside the Faraday cage. This is one of the most effective methods to reduce noise.

9.2.3 Cables

Cables should not be unnecessarily long, since they act as antennas for noise, but the cable delivered with your instrument has an inbuilt shield and as long as you use the original cable, there is little reason to worry about cable induced noise.

9.2.4 Contacts

Check if the contacts are corroded. If so, remove the stains, for example with sandpaper.

9.2.5 Grounding

See also section **Chassis ground**.

The best way to connect the ground of your equipment is star-shaped, where all parts are connected with the ground at the same point. In an electrochemical lab that point is usually the faraday cage. This way earth loops that induce noise are avoided.

9.2.6 Network

If your instrument cannot connect via the LAN network, please make sure your instrument is in the same network as your computer. The instrument communicates via port 49152, make sure this port is not blocked by the firewall of your pc or in your network.

10 Self-Diagnostics

The Nexus supports self-diagnostics from firmware v1.1 and on. Check the Nexus LCD or the Instrument Settings window in PSTrace to see which firmware version the instrument is running. The 'Self Diagnostics Tool' generates a report that gives a detailed overview of possible malfunctions. This report can be exported to a Word document and sent by email (**info@palmsens.com**) to PalmSens BV in case there's doubt about the functioning of your Nexus.

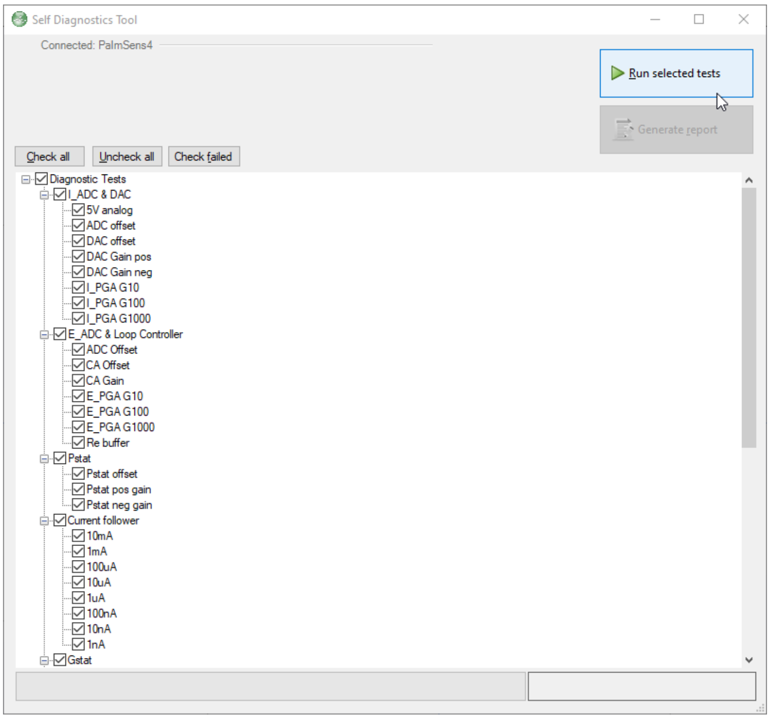
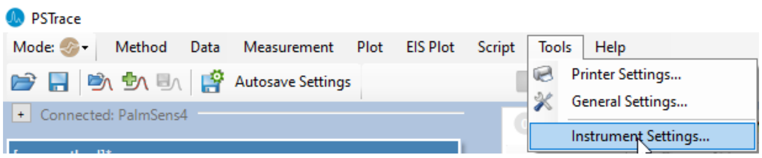


Figure 17 The 'Self Diagnostics Tool' window

To run the self-diagnostics tool go to the menu: 'Tools' → 'Instrument Settings...' and click the button 'Self Diagnostics'. Follow the instructions shown on the screen.



A. EU Declaration of conformity

PalmSens

EU DECLARATION OF CONFORMITY

CE

Certificate number: PSDOC-NXS-A

Manufacturer: PalmSens BV
Address: Vleugelboot 22,
3991 CL Houten,
The Netherlands

This declaration is valid for the following product:

Nexus (Nexus V1.0 and higher)
Electrochemical analyser

- USB and ethernet and communications
- Mains to 12V power adaptor
- 1 meter cell cable
- Screen display

The object of the declaration described above is in conformity with the Electromagnetic-Compatibility Directive 2014/30/EU (EMCD), the Low Voltage Directive (LVD) (2014/35/EU) and applicable standards listed below:

3.1a Health & Safety

- EN 61010-1

3.1b EMC

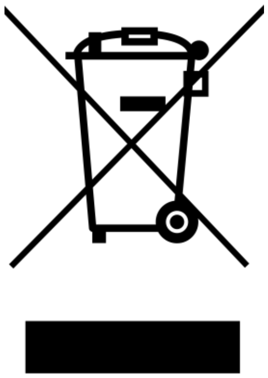
- EN 61326-1

This declaration is issued under the sole responsibility of PalmSens BV.

Date: 17th of January 2025

C.J. van Velzen, CTO

B. EU Waste Electrical and Electronic Equipment (WEEE) Directive



The pictogram shown above, located on the product(s) and / or accompanying documents means that used electrical and electronic equipment (WEEE) should not be mixed with general household waste. For proper treatment, recovery and recycling, please take this product(s) to designated collection points where it will be accepted free of charge.

Alternatively, in some countries, you may be able to return your products to your local retailer upon purchase of an equivalent new product. Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling. Please contact your local authority for further details of your nearest designated collection point. Penalties may be applicable for incorrect disposal of this waste, in accordance with your national legislation.

11 Licenses

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https://www.freertos.org/Documentation/02-Kernel/01-About-the-FreeRTOS-kernel/04-Licensing

eyalroz/printf (MIT):

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