Go Direct® Nitrate Ion-Selective Electrode

(Order Code GDX-NO3)

Go Direct Nitrate Ion-Selective Electrode (ISE) is used to measure the concentration of nitrate (NO_3^-) ions in aqueous samples.

Note: Vernier products are designed for educational use. Our products are not designed nor are they recommended for any industrial, medical, or commercial process such as life support, patient diagnosis, control of a manufacturing process, or industrial testing of any kind.

What's Included

- Go Direct Nitrate Ion-Selective Electrode (Go Direct Ion-Selective Electrode Amplifier connected to a Go Direct Nitrate Ion-Selective Electrode BNC)
- Micro USB cable
- 30 mL bottle of High Standard solution with SDS (100 mg/L NO_3- as N)
- 30 mL bottle of Low Standard solution with SDS (1 mg/L NO_3- as N)
- Short-Term ISE Soaking Bottle

Compatible Software

See **www.vernier.com/manuals/gdx-no3** for a list of software compatible with the Go Direct Nitrate Ion-Selective Electrode.

Quick Start: Vernier Graphical Analysis® and Bluetooth®

1. Charge your sensor for at least 2 hours before first use.
2. Prepare the electrode by soaking it in the High Standard solution for 30 minutes. Refer to the Using the Product section for more information.
3. Turn on your sensor. The LED will blink red.
4. Launch Graphical Analysis, then click **Sensor Data Collection**.
5. Select your sensor from the list. The sensor ID is located on the sensor label near the bar code. **Note**: If you don't see a list of available sensors, click **WIRELESS**. After selecting your sensor, click **Pair**.
6. Click **DONE**. You are now ready to collect data.
7. For best results, perform a two-point calibration using the High and Low Standard solutions.

Using other Vernier data-collection apps or want to connect via USB?

Visit **www.vernier.com/start-go-direct**

Note: This sensor also works with LabQuest 2 and LabQuest 3; it does not work with the original LabQuest.

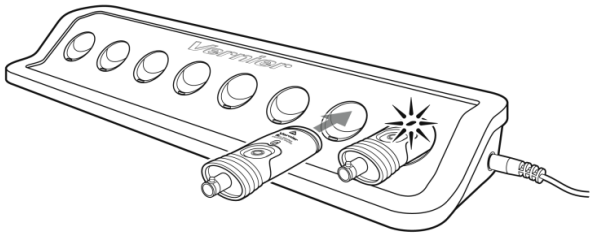
Please see the following link for platform-specific connection information:

www.vernier.com/start/gdx-no3

Charging the Sensor

Connect the Go Direct Nitrate Ion-Selective Electrode to the included Micro USB Cable and any USB device for two hours. Connecting the Go Direct Nitrate BNC Electrode to the amplifier during charging is optional.

You can also charge up to eight Go Direct Nitrate Ion-Selective Electrodes using our Go Direct Charge Station, sold separately (order code: GDX-CRG). An LED on each Go Direct Nitrate Ion-Selective Electrode indicates charging status.



Charging	Blue LED on steady while sensor is connected to the Micro USB Cable or Charge Station.
Fully charged	Blue LED is off when charging is complete.

Powering the Sensor

Turning on the sensor	Press button once. Red LED indicator flashes when unit is on.
Putting the sensor in sleep mode	Press and hold button for more than three seconds to put into sleep mode. Red LED indicator stops flashing when sleeping.

Connecting the Sensor

See the following link for up-to-date connection information:

www.vernier.com/start/gdx-no3

Connected and charging	Blue and Green LED solid when sensor is connected to Graphical Analysis via USB and unit is charging. (Green LED is obscured by the blue one.)
Connected, fully charged	Green LED solid when sensor is connected to Graphical Analysis via USB and the unit is fully charged.
Charging via USB, connected via Bluetooth	Blue LED is solid and green LED is flashing, but the green flashing LED looks white because it is overwhelmed by the blue.

Identifying the Sensor

When two or more sensors are connected, the sensors can be identified by tapping or clicking Identify in Sensor Information.

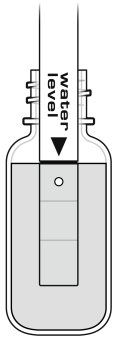
Using the Product

1. Remove the storage bottle from the electrode by unscrewing the lid and removing the bottle and lid.
2. Thoroughly rinse the lower section of the probe using distilled or deionized water.
3. Soak the tip of the electrode for 30 minutes in the High Standard solution.
   - The ISE should not rest on the bottom of the container.
   - The small white reference contacts near the tip of the electrode should be immersed.
   - Make sure no air bubbles are trapped below the ISE.
4. Connect the sensor following the steps in the Quick Start section.
5. For best results, perform a two-point calibration using the High and Low Standard solutions. For calibration instructions, see **www.vernier.com/til/4011**
6. When you are finished making measurements, rinse the electrode with distilled water.
7. Slide the cap onto the electrode body, and then screw the cap onto the storage bottle so the tip of the electrode is not touching the sponge.

Important: Do not fully submerge the sensor. The BNC connection is not waterproof.

Important: Do not leave the ISE soaking for more than 24 hours.

Note: If the ISE needs to be transported to the field during the soaking process, use the Short-Term ISE Soaking Bottle. Remove the cap from the bottle and fill it 3/4 full with High Standard. Slide the bottle's cap onto the ISE, insert it into the bottle, and tighten it. For long-term storage, greater than 24 hours, make sure the sensor is stored in its storage bottle with the sponge slightly damp.



Channels

Go Direct Nitrate Ion-Selective Electrode has six sensor channels. The channel names are

- Potential (mV)
- Chloride (mg/L)
- Ammonium (mg/L)
- Calcium (mg/L)
- Nitrate (mg/L)
- Potassium (mg/L)

Note: The Nitrate channel is the default channel for this sensor. All channels are mutually exclusive except Potential (i.e., You can display one concentration channel and Potential at the same time, but you cannot display two concentration channels at the same time). In order to collect data from the other concentration channels, you must also attach the applicable corresponding BNC electrode to the amplifier.

Calibrating the Sensor

A calibration is stored on each sensor before it is shipped. As the membrane ages, this factory calibration may become inadequate. For best results, we recommend performing a two-point calibration.

Note: If you plan to use the electrode outside the range of the standards provided, you will need to prepare your own standards and use those for soaking and calibration. Standards should be two decades apart (e.g., 5 mg/L and 500 mg/L).

For additional calibration information, see **www.vernier.com/til/4011**

Specifications

Range	1 to 14,000 mg/L (or ppm)
Accuracy after calibration	±10% of full scale (calibrated 1 to 100 mg/L)
Interfering ions	ClO_4^-, I^-, ClO_3^-, F^-
pH range	2–11 (no pH compensation)
Temperature range	0–40°C (no temperature compensation)
Electrode slope	–56 ±3 mV/decade at 25°C
Standard voltages, typical	High (100 mg/L) is 44 mV and Low (1 mg/L) is 160 mV
Electrode resistance	0.1 to 5s MΩ
Minimum sample size	must be submerged 1.1 in (2.8 cm)
USB specification	2.0
Wireless specification	Bluetooth 4.2
Maximum wireless range	30 m
Battery	300 mA Li-Poly
Battery life (single full charge)	~24 hours
Battery life (long term)	~500 full charge cycles (several years depending on usage)

Care and Maintenance

Proper care and storage are important for optimal longevity of your Nitrate ISE.

- Long-term storage of the ISE (longer than 24 hours): Moisten the sponge in the bottom of the long-term storage bottle with distilled water. When you finish using the ISE, rinse it off with distilled water and blot it dry with a paper towel. Loosen the lid of the long-term storage bottle and insert the ISE. **Note:** The tip of the ISE should NOT touch the sponge. Also, make sure the white reference mark is inside the bottle. Tighten the lid. This will keep the electrode in a humid environment, which prevents the reference junctions from completely drying out.
- Put the device in sleep mode by holding the button down for at least three seconds. The red LED will stop flashing to show that the unit is in sleep mode. Over several months, the battery will discharge but will not be damaged. After such storage, charge the device for a few hours, and the unit will be ready to go.
- Short-term wet storage (less than 24 hours): Fill the Short-Term ISE Soaking bottle 3/4 full with High Standard. Loosen the cap, insert the electrode into the bottle, and tighten.

Note: Exposing the battery to temperatures over 35°C (95°F) will reduce its lifespan. If possible, store the device in an area that is not exposed to temperature extremes.

Maintaining and Replacing the ISE Standard Calibration Solutions

Having accurate standard solutions is essential for performing good calibrations. The two standard solutions that were included with your ISE can last a long time if you take care not to contaminate them. At some point, you will need to replenish your supply of standard solutions. Vernier sells replacement standards in 500 mL volumes. Order codes are:

- NO3-LST: Nitrate Low Standard, 1 mg/L
- NO3-HST: Nitrate High Standard, 100 mg/L

To prepare your own standard solutions, use the information in the table below. **Note:** Use glassware designed for accurate volume measurements, such as volumetric flasks or graduated cylinders. All glassware must be very clean.

Standard Solution	Concentration (mg/L or ppm)	Preparation Method using High Quality Distilled Water
Nitrate (NO_3^-) ISE High Standard	100 mg/L NO_3 as N	0.607 g Na NO_3 / 1 L solution
Nitrate (NO_3^-) ISE Low Standard	1 mg/L NO_3 as N	Dilute the High Standard by a factor of 100 (from 100 mg/L to 1 mg/L).*

*Perform two serial dilutions as described below.

a. Combine 100 mL of the High Standard with 900 mL of distilled water. Mix well.
b. Combine 100 mL of the solution made in Step a with 900 mL of distilled water. Mix well.

Replacement Modules

The Go Direct Nitrate Ion-Selective Electrode has a PVC membrane with a limited life expectancy. It is warranted to be free from defects for a period of twelve (12) months from the date of purchase; it is possible, however, that you may get somewhat longer use than the warranty period. If you start to notice a reduced response, it is probably time to replace the membrane module. **Important:** Do not order membrane modules far in advance of the time you will be using them; the process of degradation takes place even when they are stored on the shelf.

Battery Information

The Go Direct Nitrate Ion-Selective Electrode contains a small lithium-ion battery in the handle. The system is designed to consume very little power and not put heavy demands on the battery. Although the battery is warranted for one year, the

expected battery life should be several years. Replacement batteries are available from Vernier (order code: GDX-BAT-300).

Water Resistance

The Go Direct Nitrate Ion-Selective Electrode is not water resistant and should never be immersed in water above the BNC junction.

If water gets into the device, immediately power the unit down (press and hold the power button for more than three seconds). Disconnect the sensor and charging cable, and remove the battery. Allow the device to dry thoroughly before attempting to use the device again. Do not attempt to dry using an external heat source.

How the Sensor Works

Combination Ion-Selective Electrodes consist of an ion-specific (sensing) half-cell and a reference half-cell. The ion-specific half-cell produces a potential that is measured against the reference half-cell depending on the activity of the target ion in the measured sample. The ion activity and the potential reading change as the target ion concentration of the sample changes. The relationship between the potential measured with the ISE and the ion activity, and thereby the ion concentration in the sample, is described by the Nernst equation:

$$E = E_o - 2.303\frac{RT}{nF}\log(C + C_0)$$

E = measured potential (mV) between the ion-selective and the reference electrode

E_o = standard potential (mV) between the ion-selective and reference electrodes

R = universal gas constant (R = 8.314 J mol^{-1} K^{-1})

T = temperature in K (Kelvin), with T (K) = 273.15 + t °C where t is the temperature of the measured solution in °C.

F = Faraday constant (96485 C mol^{-1})

n = valence of the ion

C = concentration of ion to be measured

C_0 = detection limit

Since R and F are constant, they will not change. The electrical charge of the ion (valence) to be measured is also known. Therefore, this equation can be simplified as

$$E = E_o - S\bullet \log(C + C_0)$$

where $S = -2.303\frac{RT}{nF}$ is the ideal slope of the ISE.

The following table describes ideal behavior:

Ion Examples	*n* (valence of ion)	*S* (at 25 °C), mV/decade
Calcium (Ca^{2+})	+2	+29.58
Potassium (K^+), Ammonium (NH_4^+)	+1	+59.16
Nitrate (NO_3^-), Chloride (Cl^-)	–1	–59.16

Assuming C_0 is near zero, the equation can be rewritten as:

$$C = 10\text{^}[(E - E_o) / S]$$

allowing for the calculation of the ion concentration.

It is very important to note that this table reflects ideal behavior. Ion-selective electrodes have slopes that are typically lower than ideal. It is generally accepted that an ISE slope from 88–101% of ideal is allowable. The slope (S) is an indicator of ISE performance. If the slope changes significantly over time, it may indicate that it is necessary to replace the ISE sensor tip.

Potential *vs.* Concentration

To measure the mV readings from an aqueous sample, calibration is not required. To convert mV readings to concentration (mg/L or ppm), the software uses a modified version of the Nernst Equation:

$$C = 10\text{^}[(E - E_o) / S_m]$$

C = concentration of ion to be measured (mg/L or ppm)

E = measured potential of sample (mV)

E_o = measured potential (mV) at a C = 1 mg/L NO_3^-–N concentration

S_m = measured electrode slope in mV/decade

The value of S_m, the measured electrode slope, is determined by measuring the potential of two standard solutions, and solving the equation below:

$$S_m = -[(\text{Low Standard} - \text{High Standard}) / \#\text{ of decades*}]$$

* A decade is defined as the factor of the difference between the two standard solutions. For example, the difference between a 1 mg/L standard and a 100 mg/L standard is 2 decades (a factor of 100 difference, or 1×10^2).

Example Calculation, converting mV to mg/L

For this example, the measured quantities are shown in the chart below:

Solution	Measured Potential
1 mg/L NO_3^-–N standard	160 mV
100 mg/L NO_3^-–N standard	44 mV
unknown sample	50 mV

$$S_m = -\frac{(160\ \text{mV} - 44\ \text{mV})}{2\ \text{decades}} = -58\ \text{mV/decade}$$

C = 10^[(50 mV – 160 mV)/ –58 mV/decade] = 79 ppm NO_3^-–N

Troubleshooting

Units of Nitrate Concentration

Nitrate ion concentration is usually expressed in units of mg/L of NO_3^- as N, also known as "nitrate-nitrogen." This means that the concentration of nitrate is expressed as if the nitrate were only in the form of nitrogen itself. The standards that are included with your Nitrate ISE have concentrations of 1 and 100 mg/L of NO_3^- as N. Here is the calculation for making a 100 mg/L NO_3^- as N standard starting with solid $NaNO_3$ (as shown in Table 1). Notice that the atomic weight of N, 14.0, is used instead of the atomic weight of NO_3^-, 62.0.

$$\frac{100\ \text{mg N}}{1\ \text{L}} \times \frac{1\ \text{g N}}{1000\ \text{mg N}} \times \frac{85.0\ \text{NaNO}_3}{14.0\ \text{g N}} = 0.607\text{g NaNO}_3\text{/L solution}$$

Unpolluted waters usually have nitrate-nitrogen (NO_3^- as N) levels below 1 mg/L. Nitrate-nitrogen levels above 10 mg/L are considered unsafe for drinking water.

Test results are sometimes published in units of mg/L NO_3^- instead of NO_3^- as N. To convert 100 mg/L NO_3^- as N to mg/L NO_3^-, you would perform this conversion:

$$\frac{100\ \text{mg N}}{1\text{L}} \times \frac{62.0\ \text{g NO}_3}{14.0\ \text{g N}} = 443\text{mg/L NO}_3$$

Using Ionic Strength Adjuster (ISA) Solution to Improve Accuracy

For optimal results at low concentrations of nitrate ions, a standard method for taking measurements with the Nitrate Ion-Selective Electrode (ISE) is to add ionic strength adjuster (ISA) solutions to each of your standard solutions and samples.

Adding an ISA ensures that the total ion activity in each solution being measured is nearly equal, regardless of the specific ion concentration. This is especially important when measuring very low concentrations of specific ions. The ISA contains no ions common to the Nitrate ISE itself. **Note:** The additions of ISA to samples or standards described below do not need to have a high level of accuracy—combining the ISA solution and sample solution counting drops using a disposable Beral pipet works fine. The following are instructions for using ISA solutions with Vernier Ion-Selective Electrodes.

Use an ISA with the Nitrate ISE by adding 2.0 M $(NH_4)_2SO_4$ ISA solution (26.42 g $(NH_4)_2SO_4$ / 100 mL solution) to the NO_3^- standard or to the solution being measured, in a ratio of 1 part of ISA (by volume) to 50 parts of total solution (e.g., 1 mL of ISA to 50 mL of total solution, or 2 drops of ISA to 5 mL of total solution).

For additional troubleshooting and FAQs, see **www.vernier.com/til/665**

Repair Information

If you have followed the troubleshooting steps and are still having trouble with your Go Direct Nitrate Ion-Selective Electrode, contact Vernier Technical Support at support@vernier.com or call 888-837-6437. Support specialists will work with you to determine if the unit needs to be sent in for repair. At that time, a Return Merchandise Authorization (RMA) number will be issued and instructions will be communicated on how to return the unit for repair.

Accessories/Replacements

Item	Order Code
Electrode Storage Bottles, pkg of 5	BTL-ES
Standard High NO3 ISE Solution	NO3-HST
Standard Low NO3 ISE Solution	NO3-LST
Nitrate Replacement Module	NO3-MOD
Go Direct Nitrate Ion-Selective Electrode BNC	GDX-NO3-BNC
Go Direct ISE Amplifier	GDX-ISEA
Micro USB Cable	CB-USB-MICRO
USB-C to Micro USB Cable	CB-USB-C-MICRO
Go Direct 300 mAh Replacement Battery	GDX-BAT-300

Warranty

Warranty information for this product can be found on the Support tab at **www.vernier.com/gdx-no3**

General warranty information can be found at **www.vernier.com/warranty**

Disposal

When disposing of this electronic product, do not treat it as household waste. Its disposal is subject to regulations that vary by country and region. This item should be given to an applicable collection point for the recycling of electrical and electronic equipment. By ensuring that this product is disposed of correctly, you help prevent potential negative consequences on human health or on the environment. The recycling of materials will help to conserve natural resources. For more detailed information about recycling this product, contact your local city office or your disposal service.

Battery recycling information is available at **www.call2recycle.org**

Do not puncture or expose the battery to excessive heat or flame.

The symbol, shown here, indicates that this product must not be disposed of in a standard waste container.

Federal Communication Commission Interference Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

Reorient or relocate the receiving antenna.

Increase the separation between the equipment and receiver.

Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

Consult the dealer or an experienced radio/TV technician for help.

FCC Caution

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device may not cause harmful interference and

(2) this device must accept any interference received, including interference that may cause undesired operation

RF Exposure Warning

The equipment complies with RF exposure limits set forth for an uncontrolled environment. The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. You are cautioned that changes or modifications not expressly approved by the party responsible for compliance could void your authority to operate the equipment.

IC Statement

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:

(1) this device may not cause interference, and

(2) this device must accept any interference, including interference that may cause undesired operation of the device.

Industry Canada - Class B This digital apparatus does not exceed the Class B limits for radio noise emissions from digital apparatus as set out in the interference-causing equipment standard entitled “Digital Apparatus,” ICES-003 of Industry Canada. Operation is subject to the following two conditions: (1) this device may not cause interference, and

(2) this device must accept any interference, including interference that may cause undesired operation of the device.

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.

RF exposure warning: The equipment complies with RF exposure limits set forth for an uncontrolled environment. The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Le présent appareil est conforme aux CNR d’Industrie Canada applicables aux appareils radio exempts de licence. L’exploitation est autorisée aux deux conditions suivantes :

(1) l’appareil ne doit pas produire de brouillage, et

(2) l’appareil doit accepter tout interférence radioélectrique, même si cela résulte à un brouillage susceptible d’en compromettre le fonctionnement.

Cet appareil numérique respecte les limites de bruits radioélectriques applicables aux appareils numériques de Classe B prescrites dans la norme sur le matériel interférant-brouilleur: “Appareils Numériques,” NMB-003 édictée par industrie Canada. L’utilisation est soumise aux deux conditions suivantes:

(1) cet appareil ne peut causer d’interférences, et

(2) cet appareil doit accepter toutes interférences, y comprises celles susceptibles de provoquer un disfonctionnement du dispositif.

Afin de réduire les interférences radio potentielles pour les autres utilisateurs, le type d’antenne et son gain doivent être choisie de telle façon que l’équivalent de puissance isotrope émis (e.i.r.p) n’est pas plus grand que celui permis pour une communication établie.

Avertissement d’exposition RF: L’équipement est conforme aux limites d’exposition aux RF établies pour un environnement non supervisé. L’antenne (s) utilisée pour ce transmetteur ne doit pas être jumelés ou fonctionner en conjonction avec toute autre antenne ou transmetteur.

Note: This product is a sensitive measurement device. For best results, use the cables that were provided. Keep the device away from electromagnetic noise sources, such as microwaves, monitors, electric motors, and appliances.

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