

Go Direct™ Acceleration (Order Code GDX-ACC)



Collect acceleration, rotation, and altitude data in the classroom or in the field. Go Direct Acceleration connects wirelessly via Bluetooth® or wired via USB to your device. This 3-axis acceleration sensor has two acceleration ranges plus an altimeter and a 3-axis gyroscope.

- Measure helmet impacts in concussion-related investigations.
- Slip it into your pocket and pirouette or ride a half-pipe.
- Zip-tie this accelerometer to your bicycle or affix it to your lab cart without any dragging cables.

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 Acceleration
- Micro USB Cable
- Shim plate for cart
- U-bracket for cart
- Cylinder mounting plate

Compatible Software

See www.vernier.com/manuals/gdx-acc for a list of software compatible with Go Direct Acceleration.

Getting Started

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

www.vernier.com/start/gdx-acc

Bluetooth Connection

1. Install Graphical Analysis 4 on your computer or Chromebook™. See www.vernier.com/ga4 for software availability.
2. Charge your sensor for at least 2 hours before first use.
3. Turn on your sensor by pressing the power button once. The Bluetooth® LED will blink red.
4. Launch Graphical Analysis 4.

USB Connection

1. Install Graphical Analysis 4 on your computer or Chromebook. See www.vernier.com/ga4 for software availability.
2. Connect the sensor to the USB port.
3. Launch Graphical Analysis 4. You are now ready to collect data.
4. To change channels, click or tap Device Manager, .

5. Click or tap Sensor Data Collection.
6. Click or tap your Go Direct sensor from the list of Discovered Wireless Devices. Your sensor's ID is located near the barcode on the sensor. The Bluetooth LED will blink green when it is successfully connected.
7. The active channel is listed in the Connected Devices Sensor Channels list. To change channels, select the check box next to the Sensor Channel(s) you would like to activate.
8. Click or tap Done to enter data-collection mode.
5. The active channel is listed in the Connected Devices Sensor Channels list. To change channels, select the check box next to the Sensor Channel(s) you would like to activate.
6. Click or tap Done to enter data-collection mode.

Charging the Sensor

Connect Go Direct Acceleration to the included Micro USB Cable and any USB device for two hours.

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

Charging	Orange LED next to battery icon is solid while sensor is charging.
Fully charged	Green LED next to battery icon solid when sensor is fully charged.

Powering the Sensor

Turning on the sensor	Press button once. Red LED indicator next to Bluetooth icon 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-acc

Connecting via Bluetooth

Ready to connect	Red LED next to Bluetooth icon flashes when sensor is awake and ready to connect.
Connected	Green LED next to Bluetooth icon flashes when sensor is connected via Bluetooth.

Connecting via USB

Connected and charging	Orange LED next to battery icon is solid when sensor is connected to Graphical Analysis via USB and the unit is charging. LED next to Bluetooth is off.
Connected, fully charged	Green LED next to battery icon is solid when sensor is connect to Graphical Analysis via USB and fully charged. LED next to Bluetooth icon is off.
Charging via USB, connected via Bluetooth	Orange LED next to battery icon is solid when sensor is connected to charger via USB and the unit is charging. Green LED next to Bluetooth icon flashes when sensor is connected via Bluetooth.

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

Connect the sensor following the steps in the Getting Started section of the user manual.

Channels

Go Direct Acceleration has 11 measurement channels:

- X-axis acceleration (m/s^2)
- Y-axis acceleration (m/s^2)
- Z-axis acceleration (m/s^2)
- X-axis acceleration - high (m/s^2)
- Y-axis acceleration - high (m/s^2)
- Z-axis acceleration - high (m/s^2)
- X-axis gyro (rad/s)
- Y-axis gyro (rad/s)
- Z-axis gyro (rad/s)
- Altitude (m)
- Angle ($^\circ$)

Acceleration

There are six acceleration channels, measured by two different chips, which are located under the 3-axis icon on the sensor label. The icon shows the positive direction for each axis, with the x-direction of acceleration parallel to the length of the sensor and the z-direction straight up through the label. Each direction of acceleration can be measured separately.

If you choose to activate three acceleration channels from one chip at once, you can create a calculated column for the total acceleration magnitude.

Gyroscope

Use the gyroscope channels to measure the rotation rate of the unit. Measured values are positive when the rotation is counter-clockwise relative to the axis directions indicated by the 3-axis icon on the label. For example, when placed label upward on a turntable rotating clockwise, the x- and y- gyroscopes will read close to zero and the z- gyroscope will show a negative reading.

If you choose to activate all three gyroscope channels at once, you can create a calculated column for the total magnitude of angular velocity.

Altitude

The altimeter channel measures altitude with a range of -1800 m to $10,000$ m. Zero the altimeter before use to measure relative height above and below your zero level.

Angle

The angle measurement channel uses the ± 16 g accelerometer chip and trigonometry to calculate the angle of the x-direction axis relative to horizontal. If you set the sensor flat on a horizontal surface with the Angle channel turned on, the green "level" LED, \odot , will glow to indicate 0° (horizontal) or 90° (vertical) inclination.

Calibrating the Sensor

Acceleration

In most cases, calibration is not necessary for this sensor. However, most accelerometers, including this one, sense gravity as well as acceleration. Thus, if you want to measure vertical acceleration separate from gravity, simply place the sensor in its measurement orientation and zero the axis that is pointing vertically upward.

If you plan to use this sensor exclusively for vertical acceleration, it makes sense to calibrate the sensor so that zeroing will not be necessary every time a new experiment is created in the software. Calibration writes an offset value to the sensor, as opposed to setting a zero temporarily for the duration of an experiment. The offset value will then be applied each subsequent time the sensor is used. To calibrate the sensor, click or tap the meter for the axis you wish to offset and choose Calibrate. Orient your sensor as for measurement and enter 0 m/s^2 (or whatever offset you choose, for example -19.6 m/s^2 if you

orient an axis vertically downward instead of upward). Click or tap Keep, then Apply the calibration.

Gyroscope

This sensor is factory calibrated.

Altitude

This sensor is factory calibrated, but you can choose to offset the value based on your physical location using the calibrate option.

Angle

This sensor is factory calibrated.

Specifications

Maximum data-collection rate	1000 sample/second (gyro and accelerometer) 2 sample/second (altimeter)
Acceleration range	±156.8 m/s ²
High acceleration range	±1960 m/s ² (± 200 g)
Gyroscope range	±34.9 rad/s
Altitude range	-1800 m to 10,000 m
Angle range	±180°
USB specification	USB 2.0 full speed
Wireless specification	Bluetooth v4.2
Maximum wireless range	30 m (unobstructed)
Dimensions	68 mm × 27 mm × 17 mm
Least cross section	28.6 mm
Battery	300 mA Li-Poly
Battery life (single full charge)	~24 hours continuous data collection
Battery life (long term)	Several years depending on usage

Care and Maintenance

Battery Information

Go Direct Acceleration contains a small lithium-ion battery. 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).

Storage and Maintenance

To store Go Direct Acceleration for extended periods of time, 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.

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.

Water Resistance

Go Direct Acceleration is not water resistant and should never be immersed in water.

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

Accelerometer

The accelerometers are microelectromechanical devices (MEMS devices) each consisting of a cantilever and a test mass. As the mass is accelerated, the cantilever bends, generating a signal proportional to the acceleration. Three orthogonal axes provide three channels of acceleration information for most experiments and an additional three channels of acceleration for high-g situations are also available. Acceleration measurements are used for the angle measurement.

Gyroscope

The gyroscope is a microelectromechanical device that uses a vibrating structure to determine rate of rotation using the Coriolis force on the structure. Three orthogonal axes provide three different channels of rotation information.

Altitude

The altimeter is a temperature-compensated, absolute air pressure sensor that can measure from 260 mBar up to 1260 mBar. We use the following equation to convert to altitude in meters:

$$\text{altitude} = 44330 \left(1 - \left(\frac{p}{p_0} \right)^{\frac{1}{5.255}} \right)$$

assuming that p_0 , the pressure at sea level, is 1013.25 mBar. The resulting altitude range is from about -1800 m to 10000 m.

The absolute pressure accuracy is ±0.2 mBar which can give you an error of ±1.4 m to ±5 m depending on which end of the scale you are at (-1800 m or 10000 m respectively).

You will often want to study the change in altitude during an experiment. Examples would include roller coaster rides, sky dives, or bungee jumps. In these cases, the absolute altitude above sea level is not as important as relative

altitude compared to the ground or to the starting point of data collection. Zero the sensor before collecting data to use relative altitude.

Additional Information about Acceleration

Since the accelerometer is sensitive to both acceleration and the Earth's gravitational field, interpreting accelerometer measurements is complex. A useful model for understanding accelerometer measurements is a spring-based scale with a reference mass (or object) attached to the scale. If the scale is pointing upward (the usual orientation for such a device) the weight of the mass causes the spring to compress, and you get a non-zero reading. If you were to turn the scale upside down, the spring will be extended, instead of compressed, and we get a reading of the opposite sign. If you turn the scale so it points sideways, and keep it motionless, then the spring will just be at its relaxed length, and the reading will be zero. If you accelerated the scale toward the mass, then the spring would compress. If you accelerate the scale away from the mass the spring would stretch. In each case the scale is reading a value corresponding to the normal force on the mass. This reading can be made relative by dividing out the mass, giving units of N/kg, which is the same as m/s^2 .

Q: What does an accelerometer measure?

A: It measures normal force per unit mass, otherwise known as proper acceleration.

Note that it's not the net force per unit mass (which is acceleration), but it is the normal force per unit mass. This somewhat unusual quantity corresponds with what a rider on a roller coaster feels during the turns. This interpretation is useful even for the scalar total acceleration value, which is 9.8 N/kg for a 3-axis accelerometer at rest, zero for one in free fall, and greater than 9.8 for one rounding a corner.

This normal force interpretation works even for a one-axis accelerometer being accelerated in a horizontal direction. The reading is non-zero as the test mass inside the device has to have a force applied to accelerate it. That's just a normal force that happens to be horizontal.

When discussing the accelerometer reading, we can call it the Normal Force per Unit Mass, with units of N/kg.

Q: I thought the accelerometer measured acceleration!

A: Here we are being very careful to not call something an acceleration when it is not a kinematic acceleration. For example, an "acceleration" of $9.8 m/s^2$ for an object that remains at rest is clearly a problematic interpretation, yet that's what the accelerometer reads.

You can correct the accelerometer reading to get a true acceleration by adding the component of the gravitational acceleration field along the direction of the sensor arrow. For example, if the axis of the accelerometer is pointing upward, then the gravitational component is $-9.8 m/s^2$. The accelerometer reads $9.8 m/s^2$ when the arrow is upward and the device is at rest. By adding $-9.8 m/s^2$, we get zero, which is the correct acceleration. If the arrow is horizontal, then the

reading is zero, but the gravitational component is zero, and we still have zero for the true acceleration.

Q: What about g-force measurements?

A: We avoid the term g-force because the quantity doesn't have units of force. Instead, g-factor can be used as a simplified label for Normal Force per Unit Mass in axis labels and discussions.

You can see that the g-factor is then 1 for an object sitting at rest on a table, zero in free fall, etc. The g-factor is dimensionless. If the Normal Force is a vector, then so is the g-factor. g-factor is completely optional—it is just a shortcut to avoid a long name.

Troubleshooting

For troubleshooting and FAQs, see www.vernier.com/til/4083

Repair Information

If you have watched the related product video(s), followed the troubleshooting steps, and are still having trouble with your Go Direct Acceleration, 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
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

Vernier warrants this product to be free from defects in materials and workmanship for a period of five years from the date of shipment to the customer. This warranty does not cover damage to the product caused by abuse or improper use. This warranty covers educational institutions only.

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 toute 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 interférent-brouilleur: "Appareils Numériques," NMB-003 édictée par Industrie Canada. L'utilisation est soumise aux deux conditions suivantes:

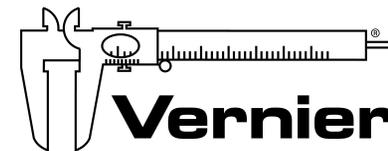
(1) cet appareil ne peut causer d'interférences, et

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

Afin de réduire les interférences radio potentielles pour les autres utilisateurs, le type d'antenne et son gain doivent être choisis 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 jumelée 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.



MEASURE. ANALYZE. LEARN.™

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