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GPS User Guide

GPS – **The Dexter Industries GPS** is a GPS unit manufactured for use with the Lego® Mindstorms® NXT. The sensor calculates positional and navigational data. It then delivers latitude, longitude, time, velocity, angle of travel, and navigational information such as distance and angle to a specified destination.

Version 4.0 Last Modified November 2010.

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GPS User Guide

Getting Started
- Hardware and Setup
- Understanding the GPS Coordinate Systems

Start Up
- Starting the Hardware and Acquiring a Signal

Software Setup
- NXT-G: GPS Read
- NXT-G: GPS Navigation
- NXT-G: GPS Angle of Travel

“Hello World”: A Quick Start

I2C Communications

Getting Started

Hardware:

Connect the GPS unit to the NXT using any of the four sensor ports.

Two types of data are sent back and forth between the NXT:

Positional Data: The GPS sensor sends data on time (UTC), latitude, longitude, velocity (in cm/s), and heading (in degrees).

Navigational Data: The NXT may be programmed to send the latitude and longitude of a desired destination or waypoint to the GPS sensor. The GPS sensor calculates the distance and angle of travel to the destination. The sensor then sends the information back to the NXT. For more accurate direction of travel data, the GPS can calculate an angle since last call.

Getting Started

Hardware:

NXT Port: Connect the GPS to the NXT here.

Reset Button: Resets the processor and temporary information.

Microcontroller: Reads GPS sensor, communicates with NXT.

Signal LED: Indicates GPS has acquired a valid satellite signal.

GPS Antenna: Receives satellite signals. Keep clear of obstructions and wires.

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Getting Started

Understanding the GPS Coordinate Systems: The Basics

Imagine the earth, divided by lines running north to south (longitude) and east to west (latitude). One can describe any place on earth with a pair of latitude and longitude coordinates. The earth is also divided into North (the northern hemisphere, north of the equator) and South (the southern hemisphere, south of the equator) and East (the eastern hemisphere, east of the Prime Meridian) and West (the western hemisphere, west of the Prime Meridian).

These coordinates are traditionally divided into degrees, minutes, and seconds.
A position is typically described in the following format: 77°04'35.54" W
(seventy-seven degrees, four minutes, thirty-five point five four seconds West).

A thorough explanation of conversion between coordinate systems can be found here:
http://en.wikipedia.org/wiki/Geographic_coordinate_conversion

Positional data from the Dexter Industries GPS is in integer decimal-degree format. Most mapping systems, like Google Maps, run on a format called "decimal degrees," where the output data looks like this: dd.mmmmmm.

Traditional Format	77°04'35.54" W
Decimal Degrees Format	-77.0765388
GPS Sensor Format	-770765388

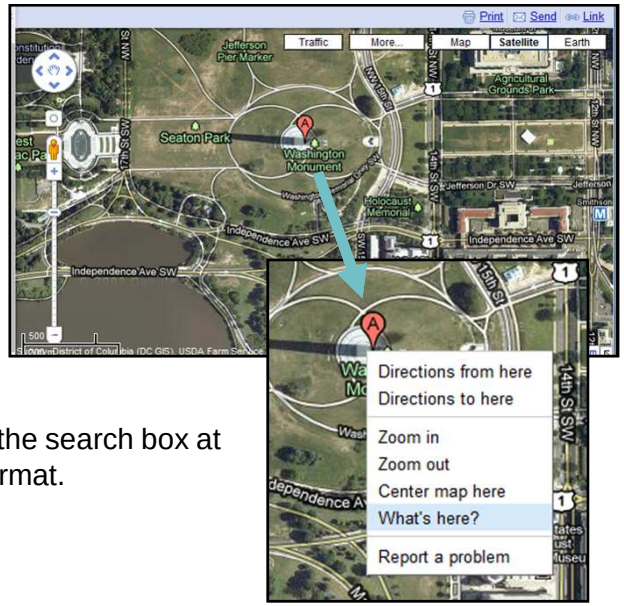
Because of NXT-G 1.0's integer math limitations, the Dexter Industries GPS sensor sends and receives data in the format ddmmmmmm. Therefore, data must be input into the GPS sensor in integer format (no decimals).

- Latitude is represented by an 8-digit integer. If the position is in the northern hemisphere, the number is positive. If the position is in the southern hemisphere, the latitude is negative.
- Longitude is represented by a 9-digit integer. If the position is in the eastern hemisphere, the number is positive. If the position is in the western hemisphere, the number is negative.

Getting Started

Understanding the GPS Coordinate Systems: An Example with Google Maps

The NXT-G software is capable of communicating with the robot, telling where it is, how far it is from its destination, and what angle it must travel to. For our example, we'll select a destination for our robot—the Washington Monument in Washington, DC.



1. Using Google maps (maps.google.com), we'll find the Washington Monument. Type Washington Monument in the search box. Right-click on the monument 's location and select **What's here?** from the pull-down menu.
2. The latitude and longitude of the Washington Monument are now displayed in the search box at the top of the page. Latitude and longitude are displayed in decimal-degree format.

   The latitude is 38.889463 and the longitude is -77.03536. That makes sense because the Washington Monument is in the northern hemisphere (latitude is positive), and the western hemisphere (longitude is negative).
3. Before using this as our destination, we must multiply both numbers by 1,000,000 to convert them to integers. The numbers we will enter into the GPS sensor are 38889463 and -7703536.

Startup

Starting the Hardware and Acquiring a Signal

The GPS unit connects to the NXT through any of the four sensor ports.

On startup, the GPS will begin searching for GPS satellites. Depending on the location and the amount of horizon visible, the GPS may take up to a minute to find a satellite signal. Acquisition time varies widely and depends on the view of the horizon, the time of day, and the number of satellites in view of your particular location. For example, if starting in a position with no obstructions and a clear view of the entire horizon, the GPS can acquire a signal in as little as 30 seconds. However, when part or all of the view is blocked, it may take the GPS longer to acquire a signal. Before a signal is acquired, the GPS will begin sending the default location and time (121000000 E, 24000000 W) until a valid signal is locked by the sensor.

The LED on the GPS unit indicates a valid GPS signal. When a signal is acquired, the LED on the GPS sensor will turn on. If satellite signals are lost, the LED will turn off. When a signal is lost, the GPS sensor will continue to transmit the location of the last valid signal. The GPS clock will continue to operate and provide an accurate time.

After locking the initial signal, the GPS sensor can retain a valid signal with limited view of the horizon. For example, in many cases, the GPS will continue to work inside a building or in a position with less view of the horizon. Upon locking the initial signal, reacquiring a signal after it is lost can take less than one second.

When the sensor is disconnected or the power to the NXT is lost, the signal must be reacquired with maximum view of the horizon.

Software Setup

NXT-G: GPS Read

The GPS Read Block can be used to read position, time, velocity, and heading.

Positional information is read by the GPS and returned in integer format.

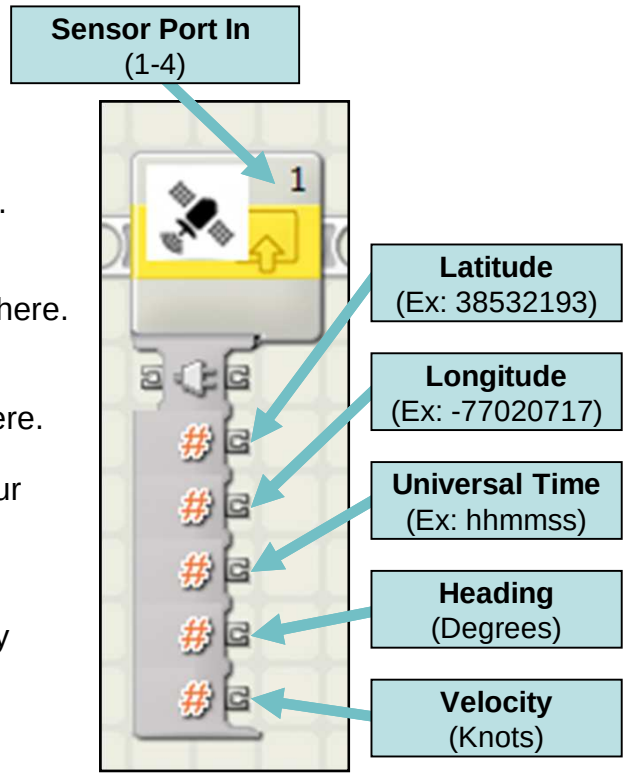
Latitude – Output is in integer/decimal degree format. Positive indicates northern hemisphere. Negative indicates southern hemisphere.

Longitude – Output is in integer/decimal degree format. Positive indicates eastern hemisphere. Negative indicates western hemisphere.

Universal Time – Output is an integer and reads hhmmss. (hour hour minute minute second second).

Heading – Integer format is a 0 to 360 degree heading of direction. Directly north is **0**. Directly east is **90**. Directly south is **180**. Directly west is **270**.

Velocity – Integer format in cm/s.



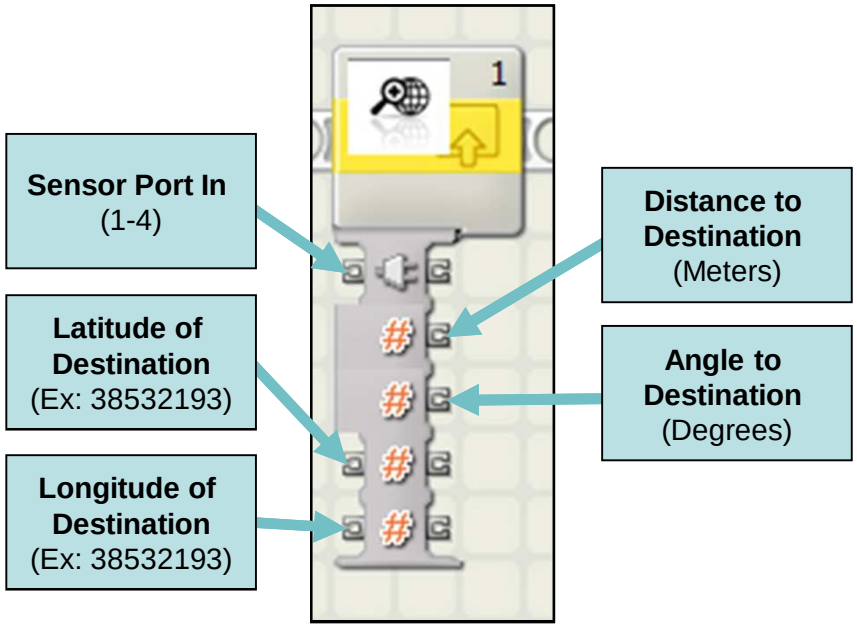
Software Setup

NXT-G: GPS Navigation

The GPS Navigation Block can be used to navigate to a user-defined destination. The destination is defined by latitude and longitude in integer format. To get a decimal degree, one can use a program such as Google Maps. (For additional information on Google Maps, see the **Using Dexter Industries GPS Sensor and Google Maps** tutorial.)

Coordinates are entered as integers.

The GPS sensor calculates the distance to the destination (in meters) and the angle to the destination (in degrees). The distance to destination and angle to destination is returned in integer format.



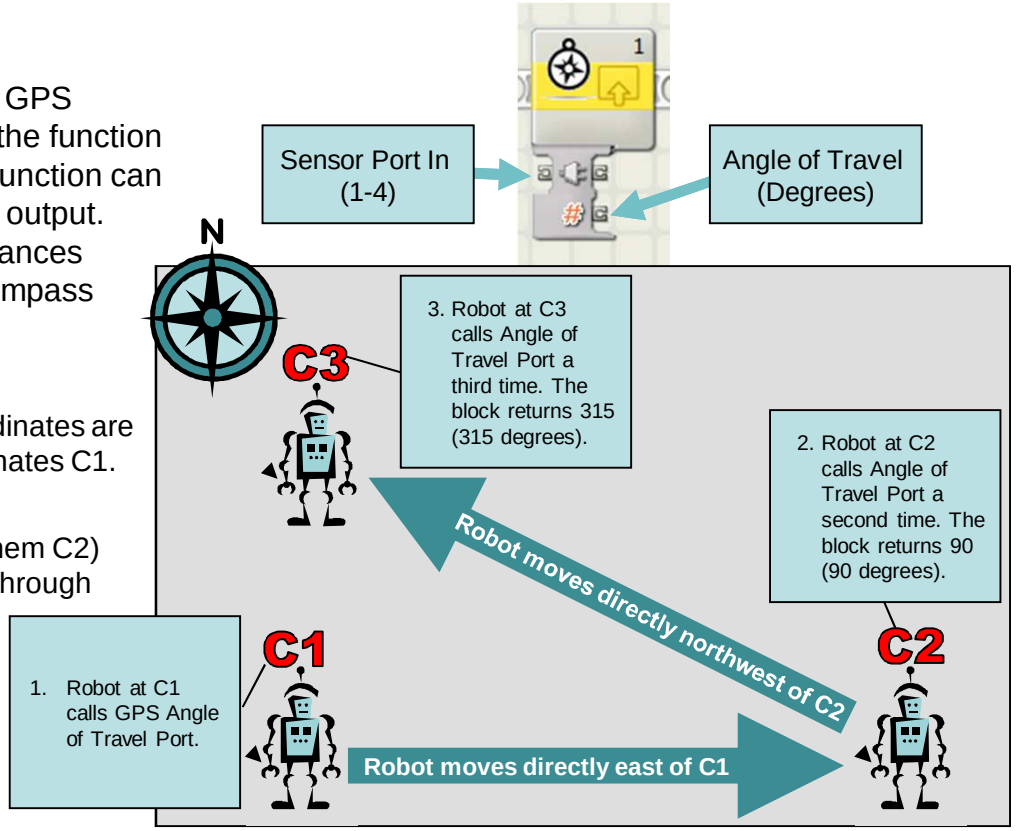
Software Setup

NXT-G: GPS Angle of Travel

The **Angle of Travel** is a function that reads the GPS position and calculates the angle traveled since the function was last called. When used over distance, this function can serve as a more precise compass than the GPS output. Calling the function intermittently over travel distances greater than 10 feet will give a more accurate compass reading.

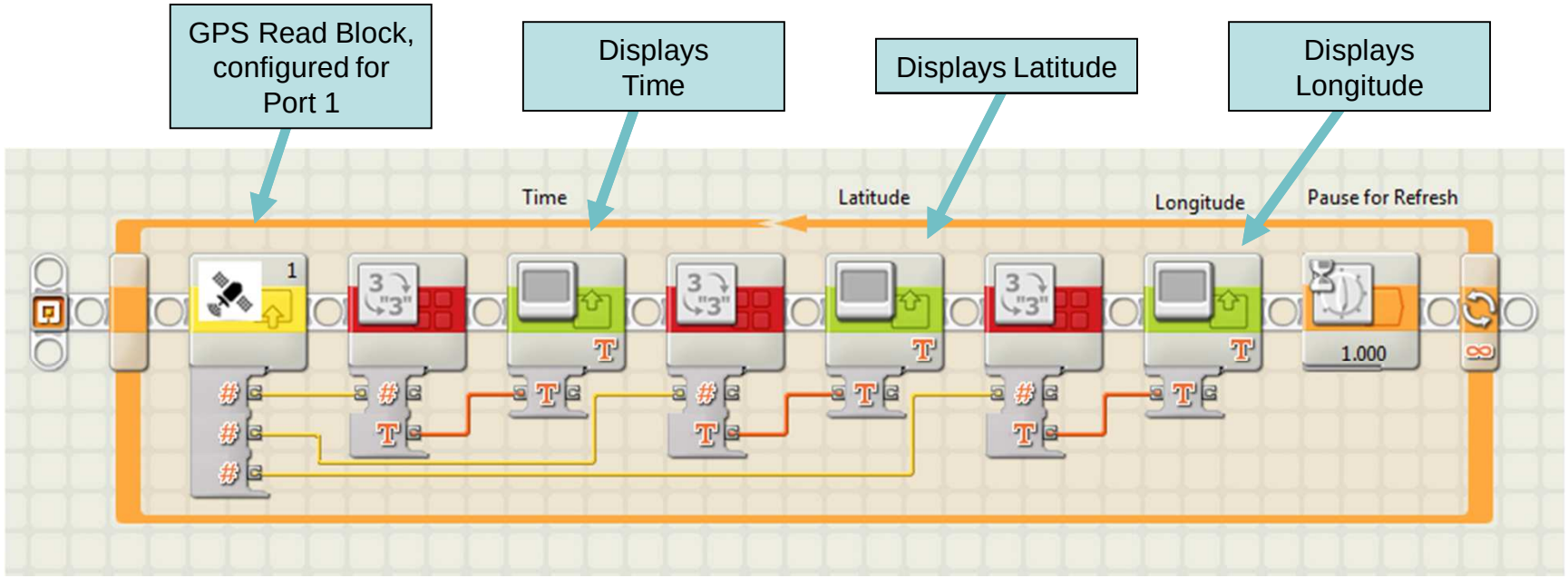
The function works as follows:

1. When the function is first called, the GPS coordinates are stored in the GPS chip. We will call the coordinates C1.
2. When the function is called a second time, the coordinates at that point are stored (we'll call them C2) and the angle between C1 and C2 is returned through the Angle of Travel Port.
3. When the function is called a third time, the coordinates at that point are stored (C3), and the angle between C2 and C3 is returned through the Angle of Travel Port.



“Hello World”: A Quick Start

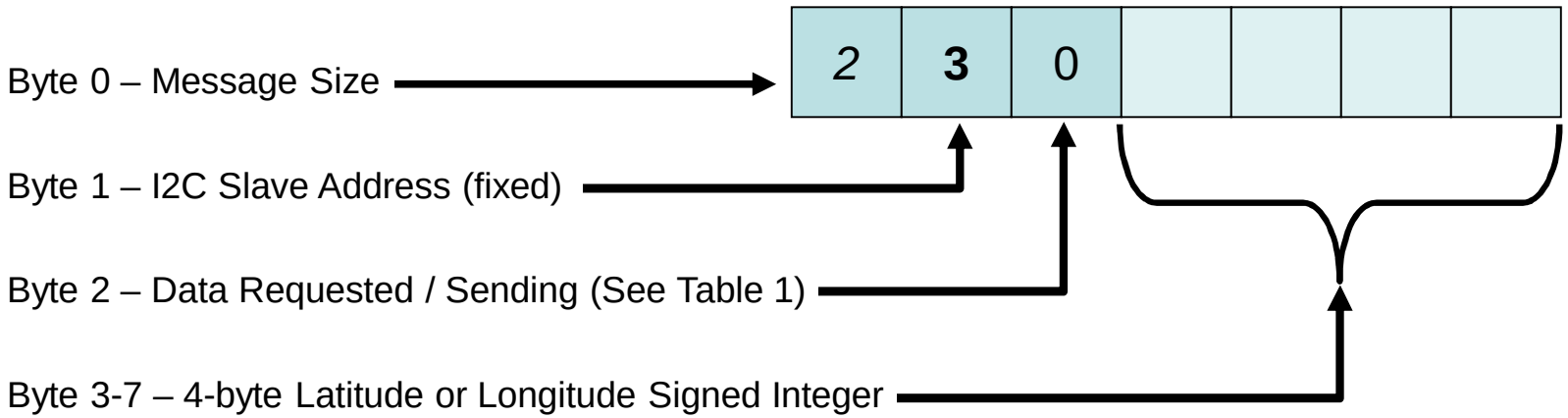
The diagram below depicts a very basic NXT-G program using the Dexter Industries GPS Sensor. The GPS Read Block is used to obtain the time, latitude, and longitude and to display these values on the screen.



I2C Communications

The NXT communicates with the Dexter Industries GPS sensor via I2C. The NXT sends seven bytes of data to the GPS. The first three bytes tell the GPS what type of data to send back to the NXT. The last four bytes are reserved for latitude and longitude of a destination.

I2C communications are diagramed in the figure below. A complete list of I2C calls are tabulated on the next page.



I2C Communications

Data Requested / Sending	Sending Size (bytes)	Receiving Size (bytes)	NXT Sends Data	NXT Receives Data
0	3	4		Time in UTC (hhmmss).
1	3	1		Status of the GPS (0 – invalid signal, 1 – valid signal).
2	3	4		Integer latitude.(ddddddddd; Positive = North; Negative = South).
4	3	4		Integer longitude (ddddddddd; Positive = East; Negative = West).
6	3	3		Velocity in cm/s.
7	3	2		Heading in degrees.
8	3	4		Distance to the destination in meters.
9	3	2		Angle to the destination in degrees.
10	3	2		Angle travelled since last request, resets the request coordinates on the GPS sensor, sends the angle of travel since the last time NXT called “10” back to the NXT.
11	7	0	Latitude	NXT sends 4-byte signed integer destination latitude to GPS sensor.
12	7	0	Longitude	NXT sends 4-byte signed integer destination longitude to GPS sensor.

Default: If the GPS sends or receives any number other than those listed in the “Data Requested / Sending” column above, it will return time in UTC.

FAQ

- **What does the button do?** - The button is a reset button. If for any reason the GPS sensor freezes, you can press this button and it will perform a soft reset. This does not reset the GPS processor and it does not reset the NXT.
- **How do I know I have a working signal?** - If you have a working signal, the blue LED will shine. It is very strong and should be noticeable.
- **How do I acquire a GPS signal?** - You can acquire a GPS signal anywhere with a view of the sky. The time to acquire the signal will depend on your location, luck, and your view of the sky. The more view of the skyline, the quicker you will acquire a signal, so a location in a flat field with no obstructions is best. An urban environment with buildings may take more time to acquire a signal. Also to consider is timing. GPS satellites orbit, and depending on the time of day you may have many satellites in view or few satellites in view. Once a signal is acquired, you may be able to maintain the signal indoors, depending on the structure you are inside. For example, we are not able to acquire a signal inside our offices. But if we place the sensor in the window we can acquire a signal, and then we are able to wander around the offices with a GPS signal.
- **Where can I acquire a GPS signal? -** You can acquire a GPS signal anywhere with a view of the sky.
- **How long does it take to acquire a GPS signal? -** Typical time to acquire a signal is about 1 minute from starting the NXT in open sky. However, it may take up to 5 minutes to acquire a signal.
- **Does the Firmware on the NXT have anything to do with catching a signal? -** Nope, nothing. You should be able to acquire a signal no matter what the firmware. The dGPS firmware is independent of the NXT firmware.
- **My program is stuck and keeps repeating the same time or location. What's wrong? -** The most likely problem is that you need a longer pause between calls to the GPS. The best way to handle this challenge is to add a 500 ms pause in between GPS sensor readings.

FAQ

Got a question? Yell at us: info@dexterindustries.com

Thanks!

We received a lot of help developing the GPS sensor. Special thanks to all that provided feedback and helped us develop the GPS sensor.

A big thanks goes out to:

Xander Soldaat	-	http://mightor.wordpress.com/
Jojoguy	-	http://lego-x.com/