Geogram ONE

Application Overview

Introduction

The Geogram ONE is an open source tracking device based off the Arduino platform. The main board comes preinstalled with an application that gives the user the ability to implement a fully functional SMS based tracking device. Some of the features included with application are:

- Locations in Google maps format
- Geofencing
- Speed monitoring
- Motion detection
- and more

Initial Hardware Setup

1. With the main battery disconnected, install an unlocked 2G SIM card into the SIM card holder on the underside of the main board.
2. Connect an appropriate cellular GSM antenna to the main board's U.FL connector.
3. Confirm the (2) two jumpers are installed on the pin headers labeled Rx and Tx next to the GPS IC.
4. (Optional) Install a 12mm coin cell backup battery for the GPS memory on the underside of the board. Please note the correct polarity of the battery before installing the battery. While this step is optional, using a backup battery for the GPS will ensure a faster time to fix if the main battery is ever disconnected.
5. Install a single cell lithium polymer battery to the main board via the 2 pin JST connector.
6. If possible, move the unit outdoors so the GPS engine can get a satellite fix and download the necessary almanac data to compute a position fix. If it's not possible to move the unit outdoors, try to place it as close as possible to

the nearest window. It can take up to 15 minutes for the GPS to get an initial satellite fix and download the necessary data. While the GPS is acquiring the signal, the LED located next to the GPS will blink. Once the GPS has a signal the LED will shut off. The last known set of valid coordinates will always be stored in memory (unless the main battery is removed) and will be updated every second.

7. Wait for the GSM to register to the cellular network. As soon as power is applied to the Geogram ONE, the onboard GSM will attempt to register the SIM card with the appropriate cellular network carrier. While attempting to register to the network, the NETLIGHT LED will flash at a fast rate (64ms On/ 800ms Off). Once the GSM connects to the appropriate network, the LED will change to a slower blink rate (64ms On/ 3000ms Off). If the unit fails to register to the network after a minute or so, try removing the main battery and reseating the SIM card.

Initial Test

Once the Geogram ONE has successfully registered to the GSM network and a satellite fix has been acquired, the device is now ready to accept commands. Each command is broken down into three separate parts: a 4 digit security PIN code, command option and one or more command parameters. Each part of the command must also end with a period (.).

The first step is to check the functionality of the Geogram ONE by sending an SMS command to the device requesting the device's location. Each command that is sent to the Geogram ONE needs to be preceded by a 4 digit security PIN code. The default PIN is 1234. Command option 0 tells the Geogram ONE to send a Google Maps link containing the longitude and latitude of the device's location back to the sender of the SMS.

Open your SMS application and send the below command to the Geogram ONE:

1234.0.

Depending on your service provider, it will usually take between 15 and 30 seconds to receive a response. You should receive a response back from the Geogram ONE containing a Google Maps link with the longitude and latitude of the device. Simply click the link and it will open up Google Maps and show the device's location.

Detailed Description of Command Options

1. **Option 0** – Send back the coordinates of the Geogram ONE formatted as a Google Maps link. There are no parameters associated with Option 0.

Example: **1234.0.**

Sample Response Back:

http://maps.google.com/maps?q=42+20.2678,-71+39.4623+(72,SW,89,GO1)&z=19
11/14/12,8:55:37p

As you can see the default response back from the Geogram ONE consists of two lines of data.

The first line gives us the Google Maps link containing the longitude and latitude of the device. The link provides other useful information contained within the parenthesis. The default settings will display the speed at which the GO is moving, the direction of travel, the percentage charge left on the battery and an identifier of the Geogram ONE module in use. As you can see from the above the example, the Geogram ONE was traveling at a speed of 72 mph in a SW direction, with a battery charge of 89% with the identifier of GO1. The information enclosed within the parenthesis is customizable through custom configuration settings in EEPROM.

The second line contains time and date information. The second line can also be configured to display additional information as described in the EEPROM configuration settings section.

2. **Option 1** – Motion detection alert. Sending a command using Option 1 to the Geogram ONE places the device into sleep mode and activates the internal motion sensor. If the device detects movement (default movement sensitivity level is set to highly sensitive), the unit wakes up and sends a user customizable message to either the sender of the request or the default SMS address stored in the EEPROM. It's important to note that while the Geogram ONE is in sleep mode, it is incapable of sending and receiving SMS messages. Since the GPS engine is also in sleep mode, it too is incapable of maintaining a satellite fix. Once the GPS wakes from sleep mode, it will attempt to lock on to the satellites. Depending on the amount of time the device is in sleep mode and device placement, the current latitude and longitude may not be immediately available. There are no parameters associated with Option 1.

   Example: **1234.1.**

3. **Option 2** – Geofence. Sending a command using Option 2 will give the user the ability to configure up to three (3) different Geofences. A Geofence is a radius defined circular area around a given point that can be used to alert the user if the Geogram ONE leaves (inside fence) or enters (outside fence) the circular region. There are several parameters associated with Option 2, each of which will be explained below.

a. Parameter 1 – Select which Geofence to program (1, 2 or 3). There are six other values available for Parameter 1 which will be explained in greater detail later.
b. Parameter 2 – Activate/deactivate the Geofence. The two values available are 0 (deactivate) and 1 (activate).
c. Parameter 3 – Inside or outside fence. The two values available are 0 (inside fence) and 1 (outside fence).
d. Parameter 4 – Radius of fence in feet (meters if changed in EEPROM) around the current location of the Geogram ONE.

It's important to note that due to the inherent inaccuracies of GPS, Geofences work best on larger areas (50 feet and above). When a Geofence area is breached, the Geogram ONE will send out a preprogrammed user definable message to the user. All configuration parameters for each Geofence are stored in EEPROM, which means even if the main battery is unplugged; all the parameters will be retained in memory.

Since the positional information (longitude, latitude and radius) for each Geofence is stored in EEPROM, there will be times when you want to simply activate or deactivate each Geofence without having to use all the above parameters. This is where the additional values associated with Parameter 1 come into play. The additional values available for Parameter 1 are:

10 – Deactivate fence 1
11 – Activate fence 1
20 – Deactivate fence 2
21 – Activate fence 2
30 – Deactivate fence 3
31 – Activate fence 3

Using these values for parameter 1 will activate/deactivate the given fence and use the positional information stored in EEPROM.

Here are just a few examples on how to configure a Geofence:

- Configure fence 1, inside fence, radius 100ft and make it active:

1234.2.1.1.0.100.

- Deactivate fence 1:

1234.2.10.

- Activate fence 3 with EEPROM values:

1234.2.31.

- Configure fence 3, outside fence, radius 350ft and make it inactive:

1234.2.3.0.1.350.

4. **Option 3** – Speed Monitoring. This activates/deactivates the speed limit monitoring option. The Geogram ONE can be configured to send out a user defined message if the device exceeds a programmed speed limit. The default firmware was shipped with this option activated set to a speed of 75 mph. There is one parameter associated with Option 3.
    a. Parameter 1 – Speed in mph (kph if changed in EEPROM). Setting the speed to zero will deactivate the speed monitoring option.

    Once option 3 is enabled, it will continually monitor the speed of the Geogram ONE. If the speed limit is exceeded, a user defined message will be sent to the user. Along with the message, a Google Maps link with the longitude and latitude of the speed limit alert will be sent to the user. After the message is sent the Geogram ONE will continue to monitor and record the maximum speed reached while above the speed limit warning value. Once the speed drops below the speed limit warning value, a second message will be sent indicating the maximum speed reached during this time along with a Google Maps link showing where the device dropped below the speed limit warning. The process then resets itself and continues to monitor the speed again until the speed limit warning value is set to zero.

    Example: **1234.3.75.** (Set speed limit to 75 mph)
    1234.3.0. (Disable speed monitoring)

5. **Option 4** – Send interval in seconds. Sending a command using option 4 will program the Geogram ONE to send the Google Maps link in constant intervals as specified by parameter 1. Setting the interval to 0 will disable the timer.
    a. Parameter 1 – Interval in seconds.

    Example: **1234.4.30.** (Send coordinates every 30 seconds)
    1234.4.3600. (Send coordinates every hour)
    1234.4.0. (Disable interval timer)

6. **Option 5** – Sleep Timer. Sending a command using option 5 will enable the sleep timer and sleep timer overrides. When the Geogram ONE is running at full power it draws a significant amount of current which limits the time the

device can operate on a single charge of the main battery. The Geogram ONE has the ability to power down/sleep specific subsystems on the main board, which, in turn, can reduce the power consumption of the device and further extend the battery life. The Geogram ONE also has the ability to override the user defined sleep timer under certain conditions. It's important to note that when selecting a time for the device to power on, it needs to be long enough for the GPS to wake up and reacquire a satellite fix. There are three parameters associated with option 5.

a. Parameter 1 – Time on (seconds). This sets the time the device remains up and running at full power. Setting this parameter to zero will disable the sleep timer.
b. Parameter 2 – Time off (seconds). This sets the time the device remains powered off/sleeping. Setting this parameter to zero will disable the sleep timer.
c. Parameter 3 – Sleep timer override. Under certain circumstances, it's beneficial to override the sleep timer function for a given application. There are three sleep timer overrides available: charger, motion and SMS. A detailed explanation of each override is as follows:

    - Charger - The microcontroller has the ability to detect when the charger (USB cable) is plugged in and powering the charging circuit. You have the option of overriding the ON/OFF timer when the charging cable is connected. With the option enabled, and the charging cable plugged in, the device will never enter sleep mode. When the charging cable is removed (or power is removed from the charging cable), the ON timer will reset to zero and your ON/OFF timer settings will go into effect.

    - Motion - The microcontroller has the ability to detect when there is motion. You have the option of overriding the ON/OFF timer when there is motion detected on the device. The motion sensing is controlled by the onboard accelerometer which can be configured to different levels of sensitivity. With the option enabled, every time the device senses motion, it will reset the timer back to zero. With no motion and having the ON timer elapse, the device will then enter sleep mode.

    - SMS (call) - With this option enabled, it will not allow the device to enter sleep mode if there is a pending SMS and will restart the timer following completion of pending SMS's. There is also a special situation with this particular setting when enabled that will have an adverse affect on total power consumption. When this option is enabled, the GSM chip will not power down when the OFF timer takes effect. The

reason being is you are giving it the option to wakeup if an incoming SMS arrives. With the option disabled, *the GSM chip will power down when the OFF timer is running and you will get the most power saving available*.

The truth table below shows the possible combinations for the three different overrides and the corresponding parameter 3 value.

Call	Motion	Charger	Param 3	Description
0	0	0	0	No overrides enabled
0	0	1	1	Charger override enabled
0	1	0	2	Motion override enabled
0	1	1	3	Motion & charger override enabled
1	0	0	4	SMS override enabled
1	0	1	5	SMS & charger override enabled
1	1	0	6	SMS and motion override enabled
1	1	1	7	SMS, motion & charger override enabled

Example:
Configure the device to wake for 5 minutes, then go to sleep for 1 hour with no overrides enabled.

1234.5.300.3600.0.

Configure the device to wake for 10 minutes, then go to sleep for 24 hours and enable charger override only.

1234.5.600.86400.1.

7. **Option 6** – EEPROM configuration settings. Most user definable settings are stored in the EEPROM of the MCU. Since the values are stored in EEPROM, the settings will remain in effect if the main battery power is disconnected. The below table shows the decimal address of each setting stored in the EEPROM.
    a. Parameter 1 – EEPROM address (decimal) of stored setting.
    b. Parameter 2 – New value to be stored at EEPROM address.

Commonly Used Settings

Address	Description	Comments
0	4 Digit PIN	4 digit security PIN code
5	Default SMS	Default SMS address. Any number up to 38 digits long.
44	Default Email	Default email address. Any email address up to 38 characters long. Note: Some GSM providers do not support email access. Please check with your provider.
83	APN	Configuration setting supplied by GSM service provider to provide access to sending an email. Default setting is 500 which is specific to T-Mobile network.
87	Configure Address	Configure reply address. 0 – reply back to sender, 1 – reply back to default SMS, 3 – reply back to default email.

88	Time Zone	Time zone setting. Example: EST is -4
89	Time/Date Format	0 – AM/PM Time Format, MM/DD/YY Date Format 1 – AM/PM Time Format, YY/MM/DD Date Format 2 – 24hr Time Format, MM/DD/YY Date Format 3 – 24hr Time Format, YY/MM/DD Date Format
90	Imperial / Metric Units	0 – Imperial Units (feet and mph) 1 – Metric Units (meters and kph)
95	Low Battery	Low Battery Alert Warning level (1 – 32) as a percentage.

Example Configuration: Configure the Geogram ONE to send all SMS messages and alerts to the number (508)555-1212. Change the security PIN code to 1973 and program the Geogram ONE to send an alert message if the battery charge falls below 15%.

1234.6.5.5085551212. (Default SMS address to (508)555-1212)
1234.6.87.1. (Send all SMS messages to default SMS)
1234.6.95.15. (Set low battery alert level to 15%)
1234.6.0.1973. (Change PIN to 1973)

Hyperlink Format Settings

Address	Description	Comments
91	Second Line Data	bit 0 – date (BWV = 1) bit 1 – time (BWV = 2) bit 2 - latitude, longitude (BWV = 4) bit 3 – speed (BWV = 8) bit 4 – course (BWV = 16) bit 5 – altitude (BWV = 32) bit 6 - hdop (BWV = 64) bit 7 - vdop (BWV = 128) bit 8 - pdop (BWV = 256) bit 9 - satellites used (BWV = 512) bit 10 - GSA Mode 2 (BWV = 1024) bit 11 - battery percent (BWV = 2048) bit 12 - battery voltage (BWV = 4096) bit 13 - rssi (BWV = 8192) bit 14 - ID (BWV = 16384) bit 15 - HTTP link* (BWV = 32768) *(setting bit 15 to a 1 will completely disable the Google Maps link from being displayed) Default: 3 BWV = Binary Weighted Value
93	First Line Data (Parenthesis)	bit 0 – date (BWV = 0) bit 1 – time (BWV = 1) bit 2 - latitude, longitude (BWV = 4) bit 3 – speed (BWV = 8) bit 4 – course (BWV = 16) bit 5 – altitude (BWV = 32) bit 6 - hdop (BWV = 64) bit 7 - vdop (BWV = 128) bit 8 - pdop (BWV = 256) bit 9 - satellites used (BWV = 512) bit 10 - GSA Mode 2 (BWV = 1024) bit 11 - battery percent (BWV = 2048) bit 12 - battery voltage (BWV = 4096)

		bit 13 - rssi (BWV = 8192) bit 14 - ID (BWV = 16384) Default: 18456 BWV = Binary Weighted Value
375	Geogram ONE ID	Can be any character (except a period) to identify the device up to 24 characters.
450	Hyperlink 1	Data used to format HTTP link. Can be up to 49 characters. Default: ***http://maps.google.com/maps?q=***
500	Hyperlink 2	Data used to format HTTP link. Can be up to 49 characters. Default: ***+(***
550	Hyperlink 3	Data used to format HTTP link. Can be up to 49 characters. Default: ***)&z=19***

Send Interval, Sleep Timer and Speed Settings

Address	Description	Comments
96	Send Interval (seconds)	0 – disable 1 - 4,294,967,296
110	Sleep Timer Overrides	See Option 5 for details.
111	Sleep Timer On	0 – disable 1 - 4,294,967,296
115	Sleep Timer Off	0 – disable 1 - 4,294,967,296
119	Speed Limit (mph/kph)	0 – disable 1 - 65,536
121	Speed Limit Hysteresis (mph/kph)	This sets the lower limit for resetting speed limit sensing after the speed limit has been passed. For example, if set to 5 and speed limit is set to 65. If the device exceeds 65mph and sends a message, it will not reset until the device drops down to 60mph (65 – 5).

Geofence Settings

Address	Description	Comments
122	Active 1 (Geofence1)	0 – disable fence, 1 – enable fence.
123	Inside/Outside 1	0 – inside fence, 1 – outside fence.
124	Radius 1 (feet/meters)	0 - 4,294,967,296
128	Latitude 1	Stored in the format *ddmm.mmmm* without the decimal point. Example: 4220.2678 -> 42202678
132	Longitude 1	Stored in the format *dddmm.mmmm* without the decimal point. Example: -7139.4623 -> -71394623
136	Active 2 (Geofence2)	0 – disable fence, 1 – enable fence.
137	Inside/Outside 2	0 – inside fence, 1 – outside fence.
138	Radius 2 (feet/meters)	0 - 4,294,967,296
142	Latitude 2	Stored in the format *ddmm.mmmm* without the decimal point. Example: 4220.2678 -> 42202678

146	Longitude 2	Stored in the format *dddmm.mmmm* without the decimal point. Example: -7139.4623 -> -71394623
150	Active 3 (Geofence3)	0 – disable fence, 1 – enable fence.
151	Inside/Outside 3	0 – inside fence, 1 – outside fence.
152	Radius 3 (feet/meters)	0 - 4,294,967,296
156	Latitude 3	Stored in the format *ddmm.mmmm* without the decimal point. Example: 4220.2678 -> 42202678
160	Longitude 3	Stored in the format *dddmm.mmmm* without the decimal point. Example: -7139.4623 -> -71394623
164	Breach Speed (mph/kph)	Minimum speed of the device before a position will be used to calculate breach of a Geofence (0 – 256). Used to minimize false data. Example using a stationary object set to 2mph: If the device speed is under 2mph, the position data will not be used in the calculation.
165	Breach Repetitions (seconds)	Number of consecutive valid times the device has breached the Geofence (0 – 256). Using a value of 10, the device would have to breach the Geofence area for 10 consecutive seconds before an alert is issued.

Accelerometer Settings

Address	Description	Comments
166	BMA250 Register 0x0F	See Bosch BMA250 datasheet for detailed explanation.
167	BMA250 Register 0x10	See Bosch BMA250 datasheet for detailed explanation.
168	BMA250 Register 0x11	See Bosch BMA250 datasheet for detailed explanation.
169	BMA250 Register 0x16	See Bosch BMA250 datasheet for detailed explanation.
170	BMA250 Register 0x17	See Bosch BMA250 datasheet for detailed explanation.
171	BMA250 Register 0x19	See Bosch BMA250 datasheet for detailed explanation.
172	BMA250 Register 0x1A	See Bosch BMA250 datasheet for detailed explanation.
173	BMA250 Register 0x1B	See Bosch BMA250 datasheet for detailed explanation.
174	BMA250 Register 0x20	See Bosch BMA250 datasheet for detailed explanation.
175	BMA250 Register 0x21	See Bosch BMA250 datasheet for detailed explanation.
176	BMA250 Register 0x25	See Bosch BMA250 datasheet for detailed explanation.
177	BMA250 Register 0x26	See Bosch BMA250 datasheet for detailed explanation.
178	BMA250 Register 0x27	See Bosch BMA250 datasheet for detailed explanation.
179	BMA250 Register 0x28	See Bosch BMA250 datasheet for detailed explanation.

*The accelerometer has several settings associated with it for setting acceleration (motion) parameters that are beyond the scope of this document. Please see the Bosch BMA250 datasheet for details on the contents of the registers. A separate document showing common parameters will be made available soon.

Alert Message Settings

Address	Description	Comments
200	Motion	Message sent for Motion Alert. Up to 24 characters.

225	Low Battery	Message sent for Low Battery. Up to 24 characters.
250	Geofence 1	Message sent for Geofence 1. Up to 24 characters.
275	Geofence 2	Message sent for Geofence 2. Up to 24 characters.
300	Geofence 3	Message sent for Geofence 3. Up to 24 characters.
325	Speed Limit	Message sent for Speed Limit. Up to 24 characters.
350	Maximum Speed	Message sent for Max Speed. Up to 24 characters.
400	D4 Interrupt	Message sent for D4 Switch. Up to 24 characters.
425	D10 Interrupt	Message sent for D10 Switch. Up to 24 characters.

Digital/Analog IO Settings

Address	Description	Comments
100	IO 0 Configuration (D4)	0 - Hi-Z/Digital In (floating input pin) 1 - Digital In w/pull up to 3.3 volts 2 - Digital Out (0) 3 - Digital Out (1) 5 - Interrupt Rising 6 - Interrupt Falling
101	IO 1 Configuration (D10)	0 - Hi-Z/Digital In (floating input pin) 1 - Digital In w/pull up to 3.3 volts 2 - Digital Out (0) 3 - Digital Out (1) 5 - Interrupt Rising 6 - Interrupt Falling
102	IO 2 Configuration (A1)	0 - Hi-Z/Digital In (floating input pin) 1 - Digital In w/pull up to 3.3 volts 2 - Digital Out (0) 3 - Digital Out (1) 4 - Analog In
103	IO 3 Configuration (A2)	0 - Hi-Z/Digital In (floating input pin) 1 - Digital In w/pull up to 3.3 volts 2 - Digital Out (0) 3 - Digital Out (1) 4 - Analog In
104	IO 4 Configuration (A3)	0 - Hi-Z/Digital In (floating input pin) 1 - Digital In w/pull up to 3.3 volts 2 - Digital Out (0) 3 - Digital Out (1) 4 - Analog In
105	IO 5 Configuration (A6)	4 - Analog In (dedicated analog pin)

There are two special configuration settings available for IO0 (D4) and IO1 (D10), interrupt rising and interrupt falling. In both of these states the pin is configured as a digital input and will constantly monitor the pin for a state change. The two possible state changes are 1 -> 0 (interrupt falling) and 0 -> 1 (interrupt rising). If the state change is met the Geogram ONE will send out a user defined message to the default address stored in EEPROM. This particular function is typically used when connecting a panic (SOS) button or monitoring an alarm signal for a real time response.

8. **Option 7** – Digital/Analog IO pins. Sending a command using option 7 gives the user access to the digital/analog IO pins on the main board. There are two parameters associated with option 7.
    a. Parameter 1 – Select IO pin address (0 – 5). IO pins 0 & 1 are configured as dedicated digital IO pins. IO pins 2, 3 and 4 can be configured as digital IO pins or analog input pins. IO pin 5 is a dedicated analog input pin only.
    b. Parameter 2 – Set state of output pin (0 – off, 1 – on) if the pin is configured as a digital output pin. If the pin is configured as a digital input or analog input, parameter 2 is not used.

    If the pin is configured as an input pin, sending a command using option 7 will report back the current state of the pin. If the pin is configured as a digital input the status will either be 0 (off – 0 volts) or 1 (on – 3.3 volts). If the pin is configured as an analog input, the value reported back will be a 10 bit decimal output (0 -1023) from the Analog to Digital converter showing the voltage level in the range of 0 to 3.3 volts.

    Example: Check the state of IO1 configured as a digital input pin.
    1234.7.1.

    Example: Set IO4 to On (3.3 volt output).
    1234.7.4.1.

    Example: Read the analog voltage applied to IO3.
    1234.7.3.