Geogram ONE

Hardware Overview

Introduction

The Geogram ONE is an open source tracking device based off the Arduino platform. The main board contains all the necessary hardware to implement a fully functional tracking device including: GPS with integrated patch antenna, quad band cellular GSM module, three axis digital accelerometer, battery charging circuit, lithium polymer fuel gauge all controlled by an Atmel ATmega328p microcontroller preinstalled with the Arduino bootloader.

While the main board comes with all necessary hardware to build a complete tracking device solution, there a few necessary, but not included items that are required for proper use. The necessary items are:

- Single Cell Lithium Polymer battery with 2 pin JST connector
- GSM antenna
- Unlocked 2G SIM card
- 3.3 volt IO FTDI cable for uploading custom firmware
- (optional) 12mm coin cell battery to backup GPS memory

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1. **GPS Module -** The GPS module consists of a 66 channel GPS engine using the MT3339 chipset. The GPS module has an integrated patch antenna that provides an ultra high (-165dBm) sensitivity which makes the device useful in covered areas. Other features of the GPS module include low power consumption, 12 multi-tone active interference canceller and a very fast time to fix. The GPS can also be put into sleep mode to further reduce power consumption (not tracking satellites) when tracking is not needed (sleep mode). There is room on the underside of the board to install an optional 12mm lithium coin cell battery to provide backup power to the GPS engine in case of loss of power. This will ensure a faster time to fix since the almanac information does not need to be downloaded again. GPS satellite fix can be

monitored by the status indicator LED directly next to the GPS module. A blinking LED indicates the GPS is attempting to acquire the necessary information from the satellites. Once the necessary position information has been received and the GPS engine is capable of computing a position, the LED will shut off.

2. **Microcontroller** – The microcontroller (MCU) used is an Atmel ATmega328p running at a clock rate of 8 MHz at 3.3 volts. The microcontroller comes preloaded with the Arduino bootloader and the most current "tracking device" sketch. Firmware (sketches) updates can be uploaded to the device in one of two ways:

    a. FTDI Cable – A standard 3.3 volt IO FTDI cable can be connected to the 6 pin header row on the bottom of the board to upload sketches. Be sure to check that the FTDI cable being used is in fact a 3.3 volt IO cable and not a 5 volt IO cable. Using a 5 volt IO cable has the potential of damaging the MCU.
    b. ISP Programmer – A standard ISP programmer can be connected to the 6 pin ICSP header row to upload firmware changes. Note: this is an advanced option and should only be used by those with knowledge and experience using ISP programmers. Uploading firmware with an ISP programmer will overwrite the Arduino bootloader and the contents of the EEPROM (tracking device settings stored in EEPROM).

3. **GSM/GPRS Module** - The GSM/GPRS module used is a SIMCom SIM900 quad-band GSM/GPRS module that supports communication over a 2G network (3G and above not supported). The board requires the use of an external antenna with a U.FL connection to connect to the cellular network. Please be sure to choose an antenna that is compatible with your particular GSM network (quad band antennas are compatible with all networks). Simply insert any 2G compatible SIM card into the SIM card holder on the underside of the board to connect to the GSM network. The board features a network registration status light (NETLIGHT) to indicate the current status of GSM network registration (fast blink rate indicates no network registration while a slow blink rate indicates successful registration to the GSM network).

4. **Power -** The power section can be broken down into three different systems:

    a. Primary Battery – The Geogram ONE is powered by any single cell lithium polymer battery which is connected to the 2 pin JST connector on the main board. It's important to note that when selecting a lithium polymer battery that it be a single cell (typically labeled as 3.7 volt) and contains the onboard protection circuitry. The majority of batteries sold today have the onboard protection circuitry, however there are still some batteries sold without it. The purpose of the protection circuitry is to guard against accidental overcharging, over discharging and accidental short circuit. The battery supplies power

directly to the GSM and the rest of the modules are powered by a regulator which is explained in the next section.

b. 3.3 Volt Regulator – With the exception of the GSM, the rest of the components on the main board receive power from a Fairchild FAN5362 high efficiency switching 3.3 volt regulator. The switching regulator has the advantage of less heat dissipation at higher current levels and longer battery life due to the inherent properties of a high efficiency switching regulator. The regulator is capable of supplying up to 750 mA of current to power any external devices that you may wish to connect to any of the available 3.3 volt pins on the main board.

c. Battery Charger – The Geogram ONE has an onboard single cell lithium polymer battery charger that receives power from a user supplied mini USB cable. Simply connect a mini USB cable to any source capable of supplying 500 mA of current (most USB ports on computers are capable of supplying this current but please check with your manufacturer first) to charge the main battery. The charging circuit will automatically stop charging when the battery has reached a full charge. It is OK to leave the USB cable connected to a power source while the device is in operation as the battery charger will turn on and off automatically when needed. There are three LEDs that show the current status of the charger and a separate POK (Power OK) signal that is connected to the MCU which can be used to detect when the USB cable is plugged into the device. It's important to note that the Geogram ONE is not designed to be solely powered from the USB connector. The charging circuit is only capable of supplying up to 500 mA of current, which is not enough to cover the 2A bursts of current draw required by the GSM module.

   Additionally, the battery charging circuit has 3 LEDs associated with it that display the current status of the charger. The charger status for the 3 LEDs (STAT1, STAT2 and PG) are as follows:

STAT1	STAT2	PG	Charger Status
OFF	OFF	OFF	No charging cable connected, battery will not charge
OFF	OFF	ON	Charging cable connected, however there is a fault. Disconnect battery and cable and try again
OFF	ON	ON	Charge complete
ON	OFF	ON	Charge in progress
ON	ON	ON	Battery is disconnected and USB is connected. Connect battery to board

5. **Battery Fuel Gauge** – The board contains a MAX17043 single cell lithium polymer battery fuel gauge that is capable of calculating the SOC (state of charge) of the main battery. The MCU can communicate with the IC and get an accurate reading of the battery SOC and voltage which can be used in firmware design. The fuel gauge also supports an external interrupt (connected to the MCU) that can be used as a low battery warning signal which is user programmable between 1 – 32% SOC.

6. **Motion Detection (Accelerometer) -** The Geogram ONE has an onboard Bosch BMA250 digital, triaxial +/- 2g to +/- 16g acceleration sensor with intelligent on-chip motion-triggered interrupt controller. The accelerometer can be programmed to detect changes in orientation (like that of a smart phone), single tap, double tap and changes in motion from a light tap (2g) up to the equivalent of an automobile crash (16g). The accelerometer has an external interrupt that is connected to the MCU and a second external interrupt that is available via a header pin (INT2).

7. **Digital and Analog IO** – Along with the vast amount of integrated hardware, the Geogram ONE gives the user the ability to interface to the outside world through the use of its digital and analog IO pins.

   Two dedicated digital IO pins are available via pin headers and are labeled D4 and D10 respectively on the underside of the board. These pins use 3.3 volt IO levels and are not 5 volt tolerant.

   The board contains four (4) 10 bit analog input pins that can be used for connecting external sensors. Please be aware that they are not 5 volt tolerant and should not have a signal larger than 3.3 volts applied or else they will be damaged. They are labeled as A1, A2, A3 and A6 respectively on the underside of the board. A1, A2 and A3 can also be configured as digital IO pins, increasing the total number of digital IO pins if needed. A6, however, is a dedicated analog input pin.

8. **Miscellaneous IO Pins** – The main board also contains several miscellaneous pins as follows:
   a. I2C – The MCU uses the I2C data bus to communicate with the onboard accelerometer and Lipo fuel gauge. The SDA and SCL lines for the I2C bus are broken out to two header pins labeled respectively on the underside of the board. It's important to note, the onboard

I2C data bus uses a 3.3 volt IO level and any external devices connected to the bus need to be at the same level. The SCL and SDA lines currently have 4.7k pull up resistors installed on the main board. While this value is sufficient for the onboard board hardware, additional pull up resistors may be required depending on the external hardware used.

b. SPI (ICSP Header) – SPI is another common communication protocol used to communicate with external hardware and as such the appropriate lines to implement the SPI standard have been made accessible as well via the ICSP header connector (the SS pin is also available but is labeled as a dedicated digital IO pin D10).
c. Speaker/Microphone – Additional hardware may be required to connect a speaker and/or microphone to the board to take advantage of voice communication through the GSM module.
d. INT2 – The onboard accelerometer contains two user programmable external interrupt pins, one of which (INT1), is hardwired to the MCU. The second interrupt pin (INT2) is connected to a single pin header giving the user external access to the programmable interrupt. Unlike other external interrupts that are typically open drain only, the INT2 pin can be configured as open drain or push pull and either active low or active high.
e. PG – The onboard battery charger generates a signal indicating when power is present on the input to the charger (USB cable plugged into a power source). This signal is routed to the MCU but is also made available for external hardware if needed.