Congr. Int. en Ing. Electrónica. Mem. ELECTRO, Vol. 43 pp.15 - 20, Oct 2021, Chihuahua, Chih. México
http:// electro.itchihuahua.edu.mx/revista
ISSN 1405-2172

# GLOBAL POSITIONING SATELLITE THROUGH EMBEDDED SYSTEMS

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## RESUMEN

**El ser humano, a lo largo de los años, siempre ha buscado la forma de viajar con seguridad lo más rápido posible a un destino deseado, para ello requiere conocer su ubicación exacta y la hora de esa zona. De tal forma que siempre se han buscado diferentes formas de conocer su ubicación. El posicionamiento global por satélite (PGS) proporciona la ubicación exacta junto con la información de la hora en todas las circunstancias climáticas, dentro de un área no especificada en la tierra con una línea de vista, sin obstáculos, en presencia de cuatro o más satélites PGS. El posicionamiento global por satélite consta de un sistema de conexión de 33 satélites. El sistema GALILEO está compuesto por una conexión de 30 satélites. El sistema PSG descrito aquí proporciona datos de posicionamiento geográfico (latitud, longitud, velocidad, dirección, fecha y hora) que se pueden ver en una computadora y también se registran en una tarjeta SD en forma de tabla.**
**Palabras Clave: GPS, Batería, Almacenamiento.**

## ABSTRACT

**The human being, over the years, has always looked for a way to travel safely as fast as possible to a desired destination, for this, it requires knowing its exact location and the time of that area. In such a way that different methods of knowing its location have always been sought. Global positioning satellite (GPS) provides exact location along with time information in all-weather circumstances, within the unspecified area on the earth followed by a line of sight in the presence of four or more GPS satellites. Global positioning satellite consists of a connection system of 33 satellites. The GALILEO System involves a connection system of 30 satellites. The GPS system described here provides geographic positioning data (latitude, longitude, speed, direction, date, and time) that can be viewed on a computer and is also recorded on an SD card in the form of a table.**
**Keywords: GPS, Battery, Logger.**

## 1. INTRODUCTION

There are approximately 31 satellites in operation at Medium Earth Orbit (12,550 miles), at any given time. This is a large system, run with careful planning and calibration. The receiver location is calculated by measuring the distance between the receiver and the satellites. This is done by multiplying the rate of signal (speed of light) by the atomic clock time on the satellite. The Receiver can get its location from three satellites, but with four satellites is more accurate, and it allows to determine receiver location in three dimensions. Three satellites are needed for x, y, and z coordinates, and one satellite to determine the time it took the signal to travel from the satellites to the receiver.

A GPS receiver is a chip that can receive an electromagnetic wave and translate it into readable data. These systems can range from a standalone chip to a breakout board, to a complete user system. A GPS module needs an antenna, an integrated system to perform math and data communication, and a communication protocol output that feeds to the user or end-system [1].

GPS communication protocols include the NMEA-0183 standard, which transforms signals into phrases. When the signal is decoded into this standard, the once-electromagnetic wave becomes readable to humans. Through the lines of text (phrases), the communication method, and the computer, the location can be displayed.

GPS has been widely used for multiple applications, some of them are cited below.

[2] proposed TrajectoryNet, a neural network architecture for point-based trajectory classification to infer real-world human transportation modes from GPS traces. To overcome the challenge of capturing the underlying latent factors in the low-dimensional and heterogeneous feature space imposed by GPS data. They achieved over 98% classification accuracy when detecting four types of transportation modes, outperforming existing models without additional sensory data or location-based prior knowledge.

In [3] they investigated the development of an embedded and mobile geographic information system. Its main characteristics concern the possibility to access various information sources and to provide the basic functionalities of a navigation system, e.g., positioning.

This system used a differential Global Positioning System (GPS) device to acquire the position of a mobile (e.g., vehicle). A cellular phone with an Internet-based connection is permitted to access distant data sources and to transfer data between the components of the system. A Web browser and a Java applet were used for data integration and visualization.

[4] described the improvement of the positioning accuracy of a GPS receiver, using software to apply the GPS to compact, hand-held devices. DGPS with a software FM demodulator, and a modified Kalman filter was proposed and applied to a GPS receiver. The positioning accuracy is 35m. with a standalone GPS, 9 m. with DGPS and, 15 m. with a Kalman filter. With both methods, the positioning accuracy was improved to 2 m.

The [5] research work explored how to avoid vehicle stealing and provided more security to the vehicles. The implemented system contained a single-board embedded system which was equipped with a global system for mobile (GSM) and global positioning system (GPS) along with a microcontroller installed in the vehicle. The use of GSM and GPS technologies allowed the system to track the object and provides the most up-to-date information about ongoing trips.

The [6]-paper presented autonomous accident prevention with security enabling techniques, speed control and accident detection system. Accident detection system comprised of GPS and GSM in cell phones. As collision occurred, a piezoelectric sensor will detect the signal and sends it to the ATmega328P microcontroller. Then, the GPS available in the smartphone started communicating with the satellite and get the latitude and longitude values and name of place of accident to be sent to the previously set phone numbers of relatives, ambulance services.

[7] proposed a system which was the integration of multiple devices, Hardware comprised of a portable system that endlessly communicates with a sensible phone that had access to the web. The System consisted of an Arduino UNO, GSM module (SIM900A), GPS module (Neo-6M), IoT module (ESP8266), Accelerometer Sensor (ADXL345), Buzzer, Panic Button, LCD. In that project, when a woman sensed danger, she had to press the Panic Button of the device. Once the system was activated, it tracked the current location using GPS (Global Positioning System) and sent an emergency message using GSM (Global System for Mobile communication) to the registered mobile number and nearby police station.

In [8]-paper they studied how powerful the low-cost embedded IMU and GPS could become for Intelligent Vehicles. The information given by the accelerometer and gyroscope was useful if the relations between the smartphone reference system, the vehicle reference system and the world reference system are known. They proposed a method to calibrate a smartphone onboard a vehicle using its embedded IMU and GPS, based on longitudinal vehicle acceleration. The results showed that the system achieved high accuracy, the typical error is 1%, and was immune to electromagnetic interference.

An intelligent hybrid scheme consisting of an Artificial Neural Network (ANN) and Kalman Filter (KF) was proposed in [9] to overcome the limitations of KF and to improve the performance of the Inertial Navigation System/Global Positioning Satellite (INS/GPS) integrated system in previous studies.

In this research work, a system has been developed based on a microcontroller that consists of a GPS, a microSD memory logger, and a battery to give power independence. The whole system can provide exact positioning, course of travel, date, and time, useful to build more sophisticated applications.

## 2. SPARKFUN GPS LOGGER SHIELD

The SparkFun GPS Logger Shield (Figure 1) teams up with the Arduino to access a GPS module, an input for a µSD memory card, and whatever other peripherals are needed to turn the Arduino into a logging device for tracking data. position, speed monitoring and altitude observation. The card is based on a GP3906-TLP GPS module: a 66-channel GPS receiver with a MediaTek MT3339 architecture and an update rate of up to 10Hz. The GPS module will transmit constant position updates through a TTL-level serial port, which you can then log onto a µSD card and/or use for other purposes.

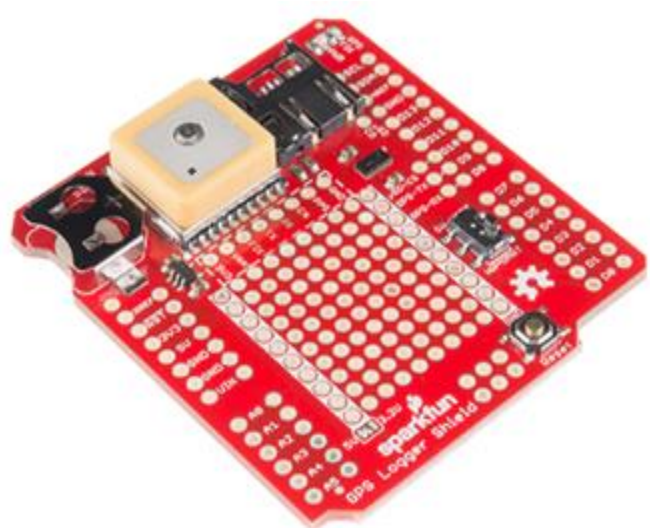


*Fig. 1 SparkFun Logger Shield Board.*

Everything on the board is highly configurable: a switch allows you to select the GPS module's UART interface between hardware or software ports, the µSD card works through a hardware SPI port, which is compatible with most Arduino designs and the additional prototype space that allows you to add other components that are needed to complete a project. The main voltage supply of the GPS Logger Shield is taken from the Arduino 5V header pin. This voltage is regulated at 3.3V, which is supplied to both the GPS module and the µSD card. These two components draw about 30 mA on average, but very occasionally they can rise to around 100 mA. A 12mm coin cell battery is also recommended, which fits into the GPS Shield battery holder [1].

### 2.1. GPS GP3906-TLP

The GP3906-TLP is a GPS POT module (figure 2) designed for ultra-low power consumption environments. It is a GPS receiver providing a solution that offers high performance in speed and position accuracy, as well as high sensitivity and tracking capacity in urban conditions. The GPS chipsets inside the module are designed by MediaTek Inc., which is the world's leading digital medium. It is a solution provider and the largest IC company. The module can support up to 66 channels. The GPS solution enables small form factor devices. They deliver breakthroughs in GPS performance, accuracy, integration, computing power, and flexibility. They are designed to simplify the integration of the embedded system [10].

*Fig. 2 GP3906-TLP.*

### 2.2. GPS's accuracy

GPS *GP3906-TLP* receiver is capable to take in the normal signals from the Global Positioning Satellite systems to achieve 3 m positional accuracy according to its datasheet [11].
When in motion, it achieves a velocity accuracy of 0.1 m/s and acceleration of 0.1 m/s$^2$. It is updated in a time of 10 ns. GP3906-TLP´s precision is shown in Table 1.

*Table 1. GP3906-TLP´s accuracy characteristics*

| | |
|---|---|
| Position | 3m |
| Velocity | 0.1 m/s |
| Acceleration | 0.1 m/s$^2$ |
| Timming | 10 ns |

### 2.3. Universal Time Coordínate (UTC)

The acronym UTC stands for Universal Time Coordinated, which was formerly called the time on Greenwich Mean Time (GMT) or Zulu time (Z). This is the local time in the Prime Meridian (i.e., the one whose longitude is 0°) given in hours and minutes on the 24-hour clock. For example, we consider the hour 1350 UTC which means 13 hours and 50 minutes after midnight, or 1:50 pm in the Prime Meridian. Next, the UTC time differences for each location will be observed (Table 2).

### 2.4. GPS 3906 Battery Supply

It is necessary to verify the battery that must be used and how to connect it for the GPS to work. A supply voltage between 2.0-4.3V is required at the VBAT pin. If you have a 12mm coin cell battery. The battery is inserted by placing it with the + side facing up.
An important note is that supplying the GP3906 with a battery backup ensures that its real-time clock (RTC) will continue to function, even when the rest of the board is powered off. That allows the module to get faster GPS solutions when it is initially powered up. It does not consume much power, around 5-6 µA, so a 12mm coin cell battery can keep the board running (in sleep mode) for about a year.

## 3. LIBRARIES

On the official page of Sparkfun [1], you look for the board called SparkFun GPS Logger Shield, with which the project is carried out, and thus you get what is necessary for the said board to work and communicate with Arduino.
In the case of the GPS 3906, you must download the TinnyGPS++ libraries to be able to add them to the Arduino and the GPS can work. For this on the Sparkfun page you must go to the link: TinyGPS Serial Streaming, from there it redirects to another link (Figure 3).

*Table 2. Time zone subtracting or adding to UTC.*

| Local time | Adjusted schedule (Hours) |
|---|---|

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http:// electro.itchihuahua.edu.mx/revista
ISSN 1405-2172

| | |
|---|---|
| Atlantic Time (ADT) | -3 |
| Atlantic Standard Time (AST)<br>Eastern Time (EDT) | -4 |
| Eastern Standard Time (EST)<br>Central Time (CDT) | -5 |
| Central Standard Time (CST)<br>Mountain Time (MDT) | -6 |
| Mountain Standard Time (MST)<br>Pacific Time (PDT) | -7 |
| Pacific Standard Time (PST)<br>Alaska Time (ADT) | -8 |
| Alaska Standard Time (ASA) | -9 |
| Hawaii Standard Time (HAW) | -10 |
| New Zealand Standard Time (NZT)<br>International Timeline (IDLT) | +12 |
| Guam Standard Time (GST)<br>Australian Eastern Standard Time (EAST) | +10 |
| Japan Standard Time (JST) | +9 |
| China Coast Time (CCT) | +8 |
| Western Australian Standard Time (WAST) | +7 |
| Russian Time Zone 5 (ZP5) | +6 |
| Russian Time Zone 4 (ZP4) | +5 |
| Russian Time Zone 3 (ZP3) | +4 |
| Baghdad Time (BT)<br>Russian Time Zone 2 (ZP2) | +3 |
| Eastern European Time (EET)<br>Russian Time Zone 1 (ZP1) | +2 |
| Central European Time (CET)<br>French Winter Time (FWT)<br>Middle Europe Time (MET)<br>Swedish Winter Time (SWT)<br>Average Winter Europe Time (MEWT) | +1 |
| Western European Time (WET)<br>Greenwich Mean Time | 0 |


TinyGPS ++

Un * NUEVO * Analizador GPS / NMEA con todas las funciones para Arduino

TinyGPS ++ es una nueva biblioteca de Arduino para analizar flujos de datos NMEA proporcionados por módulos GPS.

Al igual que su predecesor, TinyGPS, esta biblioteca proporciona métodos compactos y fáciles de usar para extraer la posición, fecha, hora, altitud, velocidad y rumbo de los dispositivos GPS de consumo.

Sin embargo, la interfaz del programador de TinyGPS ++ es considerablemente más simple de usar que TinyGPS, y la nueva biblioteca puede extraer datos arbitrarios de cualquiera de las innumerables oraciones NMEA, incluso las propias.

Descarga e instalación

Para instalar esta biblioteca, descargue aquí, descomprima el archivo en la carpeta "bibliotecas" de Arduino y reinicie Arduino. Debe cambiar el nombre de la carpeta "TinyGPSPlus".

Download

*Fig. 3 Link to download SparkFun library.*

From there it sends you to several versions that are going to be shown, version 1.0.1 is chosen as shown in Figure 4.

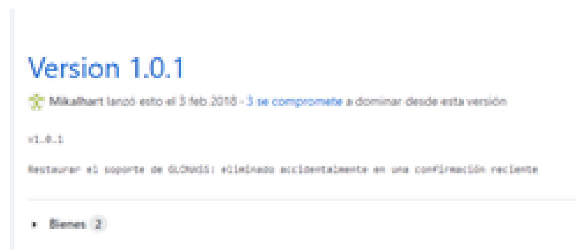
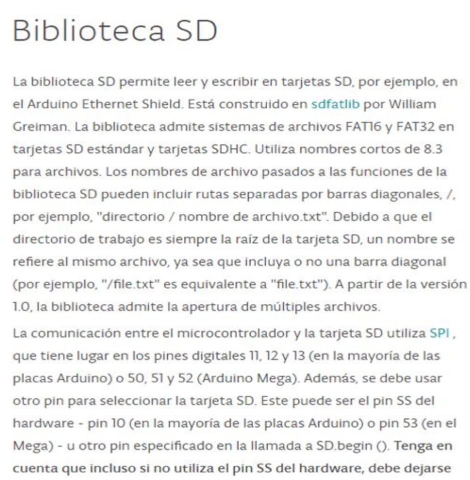

Version 1.0.1

*Fig. 4 Version used.*

For the SD library, the Sparkfun page is searched, the link is opened, and it directs you to an Arduino page that is shown in Figure 5.


Biblioteca SD

La biblioteca SD permite leer y escribir en tarjetas SD, por ejemplo, en el Arduino Ethernet Shield. Está construido en sdfatlib por William Greiman. La biblioteca admite sistemas de archivos FAT16 y FAT32 en tarjetas SD estándar y tarjetas SDHC. Utiliza nombres cortos de 8.3 para archivos. Los nombres de archivo pasados a las funciones de la biblioteca SD pueden incluir rutas separadas por barras diagonales, /, por ejemplo, "directorio / nombre de archivo.txt". Debido a que el directorio de trabajo es siempre la raíz de la tarjeta SD, un nombre se refiere al mismo archivo, ya sea que incluya o no una barra diagonal (por ejemplo, "/file.txt" es equivalente a "file.txt"). A partir de la versión 1.0, la biblioteca admite la apertura de múltiples archivos.

La comunicación entre el microcontrolador y la tarjeta SD utiliza SPI, que tiene lugar en los pines digitales 11, 12 y 13 (en la mayoría de las placas Arduino) o 50, 51 y 52 (Arduino Mega). Además, se debe usar otro pin para seleccionar la tarjeta SD. Este puede ser el pin SS del hardware - pin 10 (en la mayoría de las placas Arduino) o pin 53 (en el Mega) - u otro pin especificado en la llamada a SD.begin (). Tenga en cuenta que incluso si no utiliza el pin SS del hardware, debe dejarse

*Fig. 5 Library for SD.*

## 4. RESULTS

A program was made that uses the TinyGPS++ library to obtain the NMEA strings for position, altitude, time, and date.
Below, Figure 6 shows the GPS Logger Shield connected to the Arduino UNO.

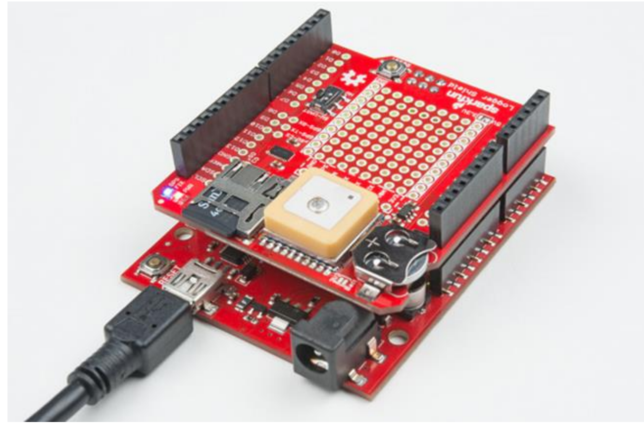


*Fig. 6 GPS Logger Shield de SparkFun.*

*Table 3 Data saved in SD.*

| 1 | longitude | latitude | altitude | speed | course | date | time | satellites |
|---|---|---|---|---|---|---|---|---|
| 2 | -106.81833 | 28.431613 | 6822.18 | 0.85 | 142.48 | 1072020 | 160635 | 7 |
| 3 | -106.81832 | 28.431563 | 6816.15 | 0.9 | 156.41 | 1072020 | 160635 | 7 |
| 4 | -106.81985 | 28.431618 | 6820.14 | 0.88 | 140.32 | 1072020 | 160635 | 7 |
| 5 | -106.81757 | 28.431819 | 6821.19 | 0.84 | 149.25 | 1072020 | 160635 | 7 |
| 6 | -106.81756 | 28.431612 | 6818.18 | 0.89 | 156.27 | 1072020 | 160635 | 7 |
| 7 | -106.81655 | 28.431314 | 6817.17 | 1 | 168.47 | 1072020 | 160635 | 7 |
| 8 | -106.81599 | 28.431536 | 6823.19 | 1.2 | 155.21 | 1072020 | 160635 | 7 |
| 9 | -106.81987 | 28.431613 | 6822.17 | 0.95 | 140.4 | 1072020 | 160635 | 6 |
| 10 | -106.81523 | 28.431518 | 6820.12 | 0.89 | 144.56 | 1072020 | 160635 | 6 |

Once the correct data is obtained from GPS, the next step is to record it on the µSD card. So, in addition to the TinyGPS++ library, the SD library built into Arduino is also used.
The system was used outdoors as buildings cause signal interference.
The results obtained from the system are shown in figure 7, where the obtained GPS data can be observed.


*Figure 7 Results viewed from the serial monitor.*

To check the correct operation obtained from the system, it is compared with a cell phone's GPS to see both data, both coincided with the same latitude and longitude. Figure 8 shows the results obtained from the cell phone's GPS.


*Fig. 8 Data thrown by a cell phone.*

Table 3 shows the data from the GPS and saved in the SD memory.

## 5. CONCLUSIONS

In this project, the expected results were obtained, the data was obtained, and it was recorded. The exact and stable location of the system was obtained, with this application positioning, navigation, monitoring, etc. can be carried out.

If the GPS program is throwing zeros or erroneous data, it is necessary to leave the interior of the building, since there is a possibility that the building in which it is located is interfering with the satellite signal with the antenna of the board. You must wait a few minutes for the program to display the correct data.

## Acknowledgements

The authors are grateful to the Tecnológico Nacional de México campus Cd. Cuauhtémoc for the support for this research.

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