GPS Series - Part 1

By Michael Simpson

Interface to a GPS Module or Receiver

I'm sure you all have had dreams of using GPS in order to give your robot the ability to determine its position. In reality, a GPS system won't help you much if you need a resolution of less than 25 feet. Nor will it help you for most indoor robot projects. However, with more and more large scale outdoor competitions a GPS system is a must. You might even want to add two systems for redundancy. There is a plethora of GPS units available. In this series, I am going to concentrate on the EM-406A, EM-408, Etek and Copernicus modules, all available from Sparkfun Electronics. I will also be looking at the Holux GPSSlim 236 module.

Each of the modules can be used with your Desktop PC, Laptop, Pocket PC, or a microcontroller. All the units support the NMEA 0183 protocol, as do many GPS modules. Later I will give you a walk through NMEA 0183 protocol.

EM-406A

Figure 1

Let's start by looking at the EM-406A module shown in Figure 1. The EM-406A is manufactured by USGlobalSat. The EM-406 is one of the modules available that has an optional development board. The development board is perfect if you are going to interface to a Desktop PC, Laptop, or Pocket PC. This makes the EM-406A a perfect starting point in the GPS series.

Let's take a quick look at the feature set of the EM-406A

- 20 Channel Receiver
- Built-in antenna
- High sensitivity: -159dBm
- 30' Positional Accuracy / 25' with WAAS
- Supports WAAS in default mode.
- Hot Start : 8 seconds
- Warm Start : 38 seconds
- Cold Start : 42 seconds
- 70mA power consumption
- 4.5 – 6.5 volt operation
- Outputs NMEA 0183 and SiRF binary protocols
- Small foot print : 30mm x 30mm x 10.5mm
- Built-in LED status indicator
- 6-pin interface cable included

We are going to start by connecting the module to our PC using the EM406 Evaluation Board shown in Figure 2. This board will allow you to use a standard AC adapter and 9-pin cable to connect the EM-406A to your PC, Laptop or Pocket PC. Sparkfun Electronics also sells a USB EM406 Evaluation Board. You may use this board as well, as it sets up a com port that you can use once it's connected to your PC or laptop. You can't use the USB board with your Pocket PC or microcontroller.

Figure 2

In order to secure your EM-406A to the evaluation board, I recommend the following steps:

Step 1

Place some double stick foam tape to the underside of the EM-406A. I recommend 4 small pieces rather than 1 large piece as shown in Figure 3. This will make it easier to remove later. One of the reasons we are using foam tape is to keep the metal bottom of the module from shorting out any of the evaluation board connections.
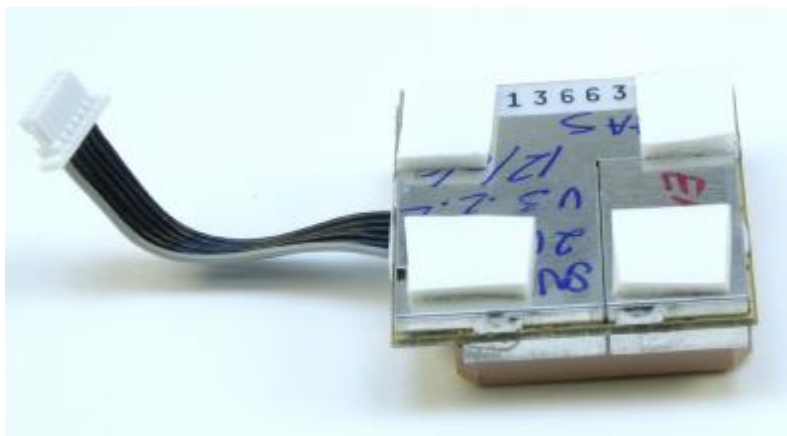
Figure 3

Step 2

Remove the backing from the foam tape and affix the module to the evaluation board as shown in Figure 4. It's ok if some of the foam tape is on top of a couple of the small components.

Figure 4

Step 3

You need to keep the bottom of the evaluation board from shorting out. One way to do this is to place small standoffs on the board as shown in Figure 5. Note that I added small nylon washers on the top to prevent the screws from shorting out any of the pads on the evaluation board.

Figure 5

Step 4

The standoffs shown in Step 3 are fine for bench top testing, or mounting on a larger surface. If you plan on using your evaluation board in your car, I recommend sandwiching the board between two pieces of plastic. Start by marking the hole for the board. This is easily done by placing the board on top of the plastic and tracing the holes. Once the holes are drilled in the bottom piece, use it to mark the top piece of plastic.

Insert four, #4 3/8" machine screws through the bottom of the base plastic piece and secure them with 4 nuts. I recommend adding 4 small nylon washers for insulation. Next, place the module on top of the screws as shown in Figure 6.

Figure 6

Step 5

Place four more nylon washers on top of the machine screws, then attach four, 1/2"
standoffs to the screws. Next, place the top piece over the standoffs and attach with four,
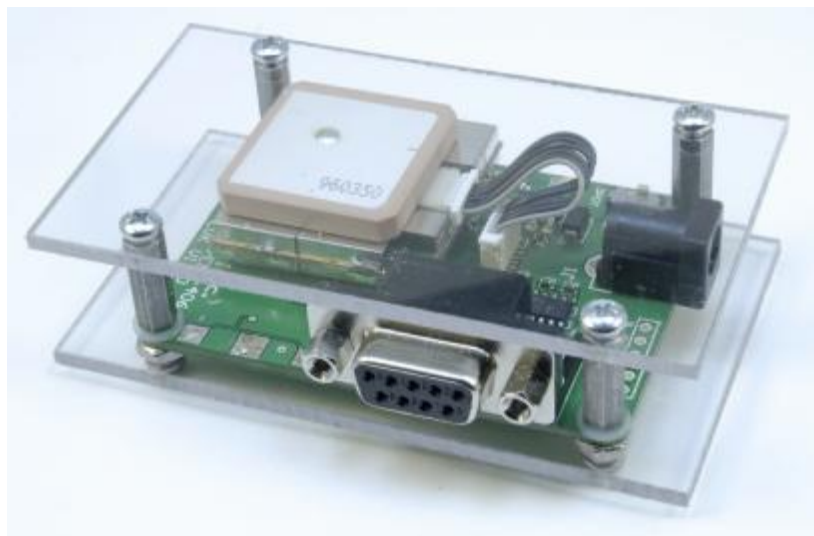#4 3/8" machine screws as shown in Figure 7.

Figure 7

EM-408

Figure 8

The EM-408 module shown in Figure 8 is also manufactured by USGlobalSat. While it does not have its own evaluation board, you can use the Copernicus Evaluation Board available from SparkFun. The EM-408 also has a built-in antenna, but also sports a MMCX connector for attaching an external antenna.

EM-408 Features

- 20 Channel Receiver
- Built-in antenna
- High sensitivity: -159dBm
- 30' Positional Accuracy / 25' with WAAS
- Supports WAAS in default mode.
- Hot Start : 8 seconds
- Warm Start : 38 seconds
- Cold Start : 42 seconds
- 75mA power consumption
- 3.3 volt operation
- Outputs NMEA 0183 and SiRF binary protocols
- 30gram weight
- Built-in LED status indicator
- 5-pin interface cable included
- External MMCX antenna connector

In order to plug the EM-408 into the Copernicus evaluation board, you need to add a couple of headers to the 5-pin connector that comes with the EM-408. Even if you don't

plan on using the Copernicus board, you will still need to mount the headers if you plan on connecting to a microcontroller, which I will detail later in this series.

Step 1

Refer to Figures 9 and 10 and add a 3-pin header attaching the Enable, Vcc and Gnd leads as shown. Mark them with different colored heat shrink so you can identify the pins later when you plug it into the evaluation board. Notice that the gray colored wire is the Enable lead.

Next, connect the two outside pins on a 3-pin header to the RX and TX leads as shown in Figure 10.
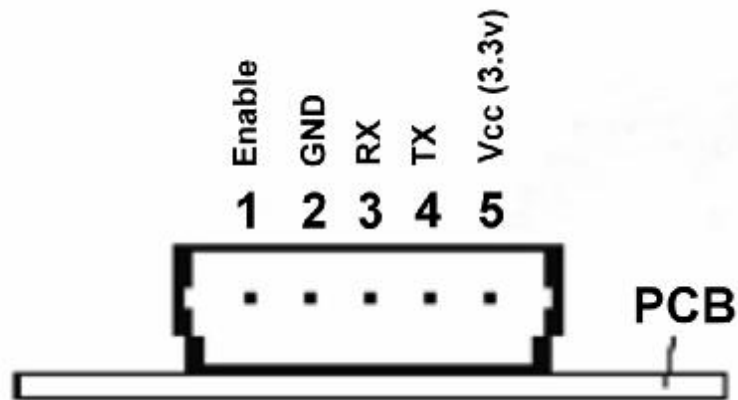

Figure 9

Figure 10

Step 2

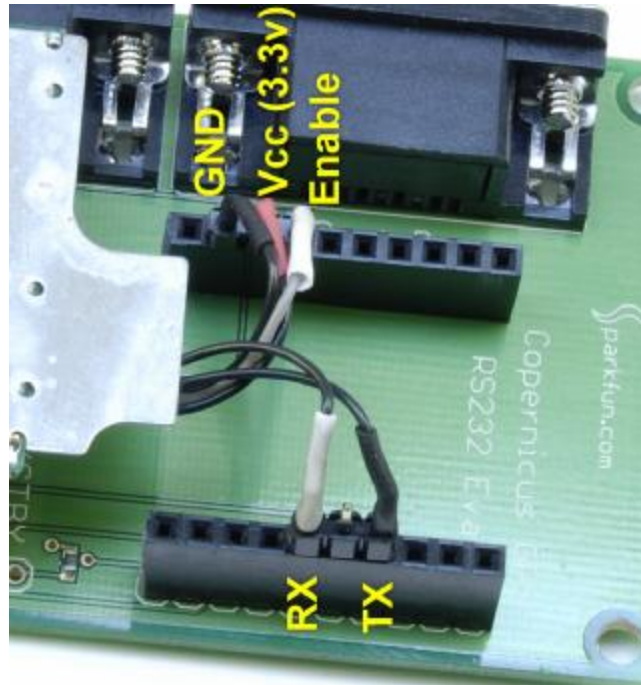Plug the male headers into the female headers on the evaluation board as shown in Figure 11.

Figure 11

Step 3

Take some double stick foam tape and attach them as shown in Figure 12. I recommend using two pieces on each to double the thickness.

Figure 12

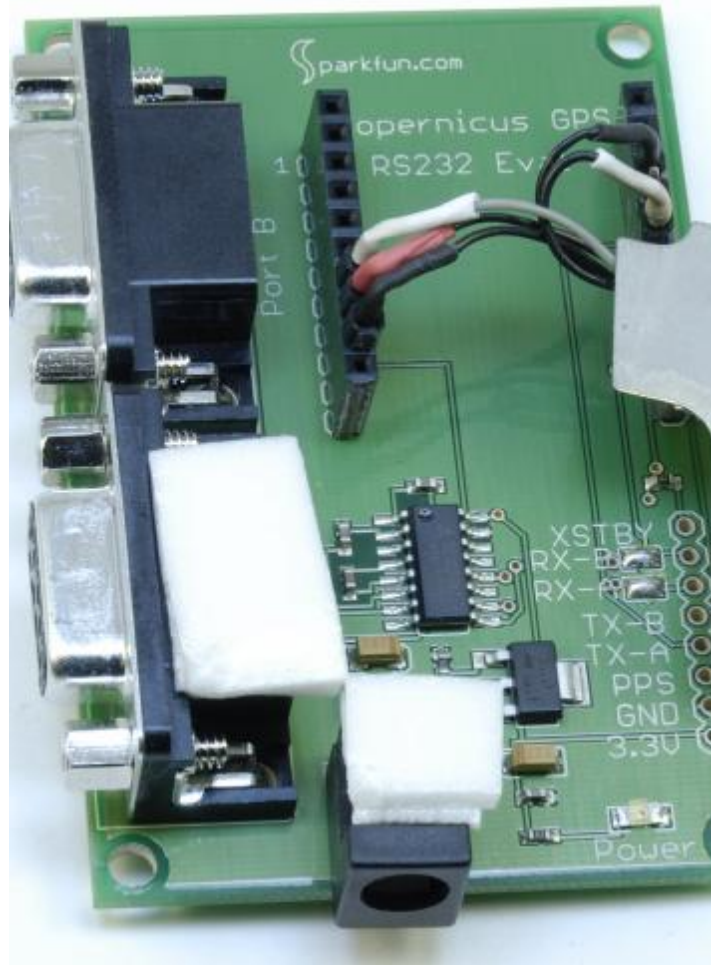## Step 4

Peel the backing from the tape and attach the EM-408 as shown in Figure 13. Make sure you do not cover the mounting holes.

Figure 13

Step 5

As I showed in the EM-406 instructions, cut two pieces of plastic and mount the Copernicus board as I outlined. The plastic should be at least 3.5" x 2.5". When finished it should look like the module shown in Figure 14.

Figure 14

When connecting to this evaluation board use Port A.

Testing the Modules

You now have a nice platform for testing your EM-406A and EM-408. All you need to do is apply power to the 2.1 coax and connect the 9-pin connector to your PC with a cable. For power, I used a small 9vDC ac adapter I had lying around (Center positive). Sparkfun sells both the AC adapter and cable if you don't already have them. Note that on the Copernicus board we used Port A.

Once you apply power to the evaluation board there is a small switch that needs to be turned on. Once on, the main power LED on the board will light. On the EM-406, the small status LED on the module will light as well.

Both the EM-406A and the EM-408 outputs its data at 4800 baud, 8N1. I have included a program called **QuickTerm_DT.exe** in the downloads. This is a simple terminal program that will allow you to see the raw NMEA 0183 data that the GPS unit is transmitting. Once you connect your module to your PC, Laptop or Pocket PC, you should see a form that looks something like Figure 15. If you don't, make sure you set the comport using the Settings menu. Even if you are deep in your basement you should still see this data coming from the module. Please note that if you are using a Pocket PC you need to use the **QuickTerm_PPc.exe** file. You will also need a null modem. (TX and RX crossover)

Figure 15

NMEA 0183 Protocol

In the old days there were as many GPS protocols as there were GPS manufacturers. Even today my Magellan Meridian has three different output protocols available. However, the NMEA 0183 protocol has evolved to become the protocol of choice for most software applications. Just about any GPS module or receiver now supports it.

The National Electrical Manufacturer Association (NMEA) has defined a series of messages. These messages are referred to at the NMEA 0183 protocol. You can download a complete NMEA 0183 reference manual here:
http://www.sparkfun.com/datasheets/GPS/NMEA%20Reference%20Manual1.pdf

Let's take a closer look at the NMEA 0183 protocol. Table 1 shows some of the NMEA messages that we will be looking at.

Message	Description
GGA	Time, Position, Fix Type
GSA	GPS receiver operating mode, Satellite used in the position solution, DOP values
GSV	The number of GPS satellites in view, Satellite ID numbers, Elevation, Azimuth, SNR values.
RMC	Time, Date, Position, Course, Speed

Table 1

A NMEA 0183 message begins with a $GP and ends with a carriage return. It looks something like this:

$GPGSV,3,1,12,20,00,000,,10,00,000,,25,00,000,,27,00,000,*79

The message name, which is also referred to as the option, are the characters just following the $GP. Each data element is separated by a comma. The data elements are terminated by the * character, followed by the checksum. There is an 8-bit XOR of Each character between the $ and * to form the checksum. The last two characters in the message are a hex representation of the calculated checksum.

Once you supply power to your GPS module it will attempt to acquire and track satellites. The GPS module needs to track at least 3 satellites in order to report its position. There are two commands the protocol uses to relay the current satellite tracking status.

GSA

Field 1, Mode (M=Manual, A=Auto)
Field 2, Fix (1=No Fix, 2=2D, 3=3D)
Fields 3-14, the satellite numbers used to calculate position.
Field 15, PDOP (Position Dilution of Precision)
Field 17 , HDOP (Horizontal Dilution of Precision)
Field 18, VDOP (Vertical Dilution of Precision)

The main field we are interested in is Field 2 (Fix). If this field value is a 1 then not enough satellites can be tracked to get a signal. If it is 2, then the module is in 2D mode. This means that only the X and Y positions can be reported. If the value is 3 then the module is in 3D mode and X, Y and Z axis positions can be reported.

GSV

Field 1, Number of Messages (1-3)
Field 2, Current Message Number (1-3)
Field 3, Satellites in View
Field 4-7, Satellite Number (1-32), Elevation (0-90), Azimuth (0-359), SNR (0-99)
Fields 8-11, Satellite Number (1-32), Elevation (0-90), Azimuth (0-359), SNR (0-99)
Fields 12-15, Satellite Number (1-32), Elevation (0-90), Azimuth (0-359), SNR (0-99)
Fields 16-19, Satellite Number (1-32), Elevation (0-90), Azimuth (0-359), SNR (0-99)

The GSV message reports the number of satellites in view and the actual signal values of any of those satellites that it is able to track. The third field reports the number of satellites in view. After that, 4 fields for each of the satellites in view report the satellite number, Elevation, Azimuth and SNR. I have provided a program called Satellites_DT.exe that will plot each satellite being tracked as shown in Figure 9. I have also included the ZeusPro source code with the download files so that you can see how I parsed the data.
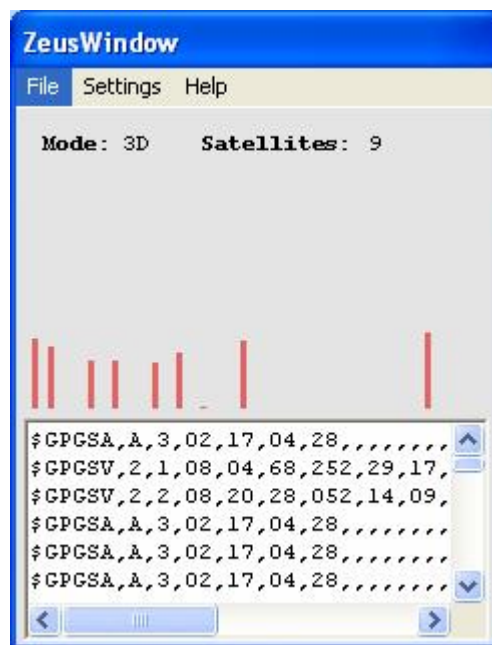

Figure 9

I have included the compiled Desktop and Pocket PC programs as well as the ZeusPro source code so that you can see how I parsed the data. As the series continues, I will continue to add programs and source code for you to experiment with.

The main function called **procNMEA,** shown in Program Segment 1, is where I test for the particular output messages and make the appropriate call to the message handler. In the segment I have also provided an example of the GGA handler.

```
func procNMEA(lndat as string)
   dim msg as string

   '----------------------------
   'Print message to console
   print lndat,len(lndat),asc(mid(lndat,1,1))

    if calcchecksum(lndat) = 0 then
      print "Checksum Error"
      exit()
    endif

   '---------------------------
   'Get msg type
   msg = replace(getword(lndat,1,1,","),"$GP","")
   select case msg
     case "GGA"
        procGGA(lndat)
     case "RMC"
        procRMC(lndat)
     case "GSA"
        procGSA(lndat)
     case "GSV"
        procGSV(lndat)
   endselect


endfunc

'-----------------------------------------
'Global Positioning System Fixed Data
'   Populates
'     GGA_UTC, GGA_Latitude, GGA_NS
'     GGA_Longitude, GGA_EW, GGA_FIX
'     GGA_SATS, GGA_Alt, GGA_AltUnit
'-----------------------------------------
func procGGA(lndat as string)
  global GGA_UTC as string
  global GGA_Latitude as string
  global GGA_NS as string
  global GGA_Longitude as string
  global GGA_EW as string
  global GGA_FIX as string
  global GGA_SATS as string
```

```
   global GGA_Alt as string
   global GGA_AltUnit as string


   GGA_UTC=getword(lndat,1,2,",")
   GGA_Latitude=getword(lndat,1,3,",")
   GGA_NS=getword(lndat,1,4,",")
   GGA_Longitude=getword(lndat,1,5,",")
   GGA_EW=getword(lndat,1,6,",")
   GGA_FIX=getword(lndat,1,7,",")
   GGA_SATS=getword(lndat,1,8,",")
   GGA_Alt=getword(lndat,1,10,",")
   GGA_AltUnit=getword(lndat,1,11,",")

endfunc
```

Program Segment 1

Final Thoughts

When you purchase a GPS module or standalone receiver you want as many channels as possible. You also want a module or receiver that supports the NMEA 0183 protocol. If you are going to connect to a microcontroller you should also look for some sort of TTL level serial output.

Before I close this article it's important that I point out that there are literally 100s of GPS modules and receivers that are available. Here are two that I have used.

Holux GPSlim236

The Holux GPSlim236 module supports a Bluetooth wireless interface. I use it with my Pocket PC and laptop for most of my trip navigation. The connector is actually a non inverting TTL serial interface that we will explore later when interfacing to microcontrollers. The GPSlim236 has a built-in battery that will power the GPS for up to 10 hours. You can also supply power to the connecter that will both charge and power the unit. This receiver will run you between $60 and $100, depending on where you purchase.

Figure 17

NAVIBE 611 Sport GPS

The NAVIBE 611 shown in Figure 18 is a small GPS module. It runs off of 2 AA batteries, or can be powered via the rear connector. I picked one of these little gems up from an eBay store for $24 new. It displays current and max speed in the small display window and spits out the NMEA 0183 protocol via a small connector. The connector supplies both a serial and USB inteface. This unit also has the ability to log GPS data for later retrieval.

Figure 18

What's Next

Next month we will look at interfacing a couple more SparkFun modules and take our NMEA 0183 interface to the next level. I will show you how to pull the positional data from the NMEA messages.

Be sure to check for updates and downloads for this article at:
http://www.kronosrobotics.com/Projects/GPS.shtml

Parts

The following is a breakdown of the source for all the components needed for Parts 2 and 3 of this project.

Spark Fun Electronics

EM-406A GPS module
http://www.sparkfun.com/commerce/product_info.php?products_id=465

EM-406 Evaluation Board
http://www.sparkfun.com/commerce/product_info.php?products_id=653

EM-408 GPS Module
http://www.sparkfun.com/commerce/product_info.php?products_id=8234

Copernicus Evaluation Board
http://www.sparkfun.com/commerce/product_info.php?products_id=8145

9-Pin Serial Cable
http://www.sparkfun.com/commerce/product_info.php?products_id=65

6V AC Adapter
http://www.sparkfun.com/commerce/product_info.php?products_id=737

External Antenna with SMA connector
http://www.sparkfun.com/commerce/product_info.php?products_id=464

SMA to MMCX adapter cable
http://www.sparkfun.com/commerce/product_info.php?products_id=285

KRMicros

ZeusPro
http://www.krmicros.com/Development/ZeusPro/ZeusPro.htm