

GPS Module Reference Design Document

Motorola Wireless Modules

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REVISION HISTORY

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1. Introduction

1.1 Purpose

This document provides a reference design for integrating a GPS receiver module into a product.

1.2 Scope

The GPS Module Reference Design applies to Motorola Wireless Modules customers designing a device that requires GPS capability in the following options:

- 1. GPS module is controlled by Host Device**
- 2. GPS module is controlled by G24 -Java**

1.3 Objectives

The objective of the GPS Module Reference Design Document is to provide a general understanding of how the GPS module is best integrated to a device.

After reading this document, the user should be able to operate the reference design board, perform testing and design his/her own application for best GPS integration.

1.4 Abbreviations

- GPS – Global Positioning System
- TCXO – Temperature Controlled Crystal Oscillator
- LGA – Land Grid Array
- LNA - Low Noise Amplifier
- TTFF – Time To First Fix
- ESD – Electrostatic Discharge



2. Overview

2.1 GPS Module Overview

The GPS Module is a GPS receiver with TCXO, 8.6x8.6x1.55mm, 32 I/O LGA, SMD, W18 compliant.

The small size GPS module makes use of a GSCi5000 IC, two saw filters, one LNA IC and other supporting components to receive and decode GPS signals using passive or active antenna structure. It contains all the functional blocks to perform Autonomous, MS-Based or MS-Assisted A-GPS.

Operating temperature range: -20 °C to +85 °C.

One Track Always (OTA or Autonomous) Performance:

- Cold Start TTFF: 60s Max
- Warm Start TTFF: 45s Max
- Hot start TTFF: 10s Max
- Acquisition sensitivity: -142 dBm Max
- Tracking sensitivity: -154 dBm Max

The fully specified GPS module data sheet is available on MOTODEV.com

2.2 Reference Design Overview

The GPS Module Reference Design board includes GPS Module receiver based on SiRF GSCi5000, DC regulators, PC connectivity (UART and USB), Headset connector and RF connector for GPS active antenna.

The GPS Module Reference Design board also includes connection to G24-Java for simulating the option of which GPS module is controlled by G24 –Java.

This design enables the following communication options:

1. **Host Device (Processor) – GPS Module** - GPS module is controlled by Host Device
2. **G24-Java (UART2) – GPS Module** – GPS module is controlled by G24 -Java
3. **G24-Java (UART2) – PC** – For MIDlet loading
4. **G24 (UART1) – Host Device** – G24 is controlled by Host Device

The G24 UART1 and UART2 can work simultaneously.

The GPS communication path can be selected by jumpers or by G24 GPIO1 and GPIO2.

3. GPS Module Reference Design Board Operation

3.1 Main Features

- Autonomous GPS receiver controlled by the following options:
 - Host Device
 - G24-Java
- Mini USB type AB connector
- SIM card holder
- 70 pin connector for G24 Module family connection
- On/Off button
- 8 lines UART1
- 4 lines UART2
- The GPS Module Reference Design board is supplied with an external antenna **Cirocomm** type: 0300130033A0800
- Headset connector for audio voice calls.

3.2 GPS Module Reference Design Board Description

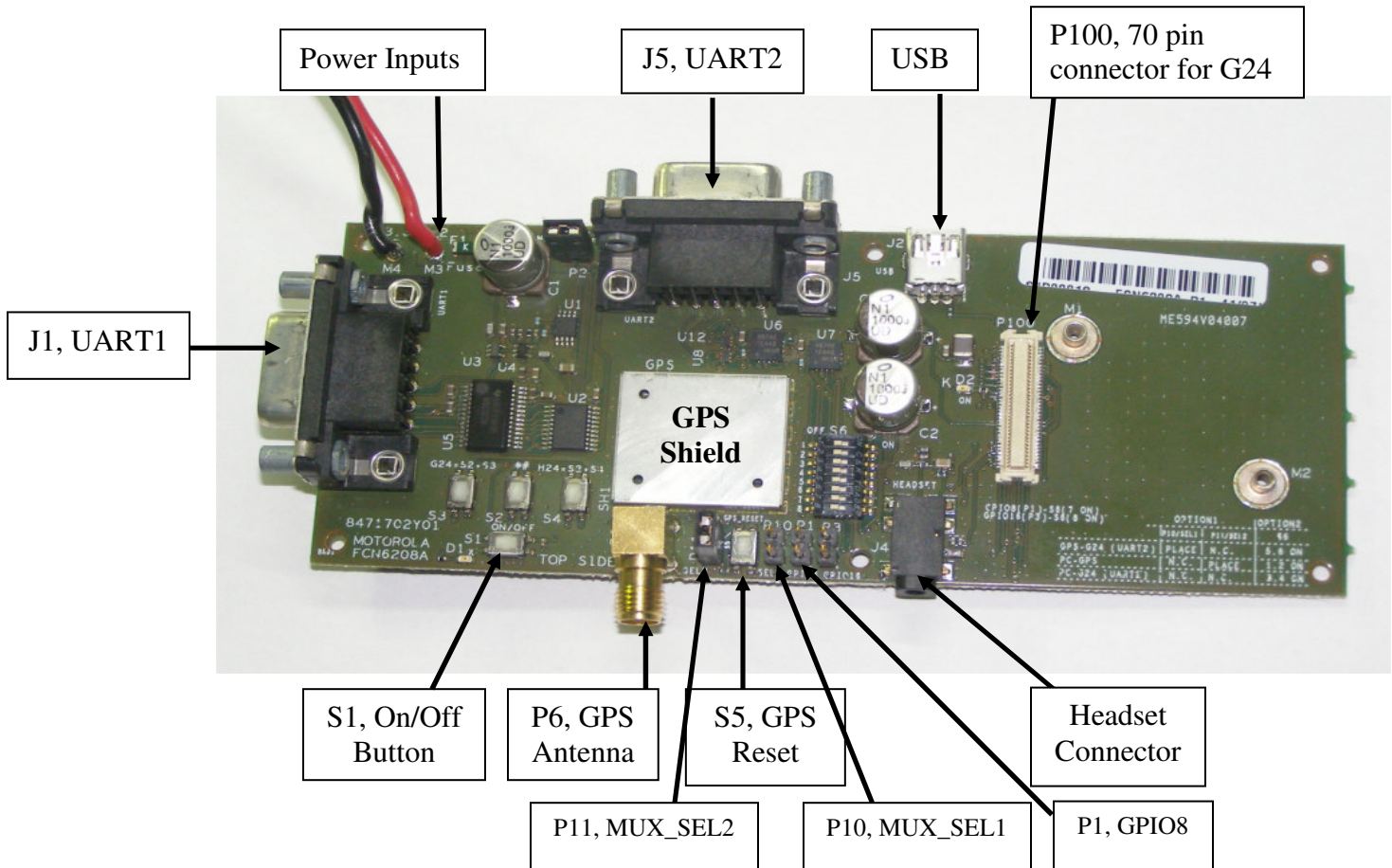


Figure 1 GPS Module Reference Design Board Description

3.3 Block Diagram

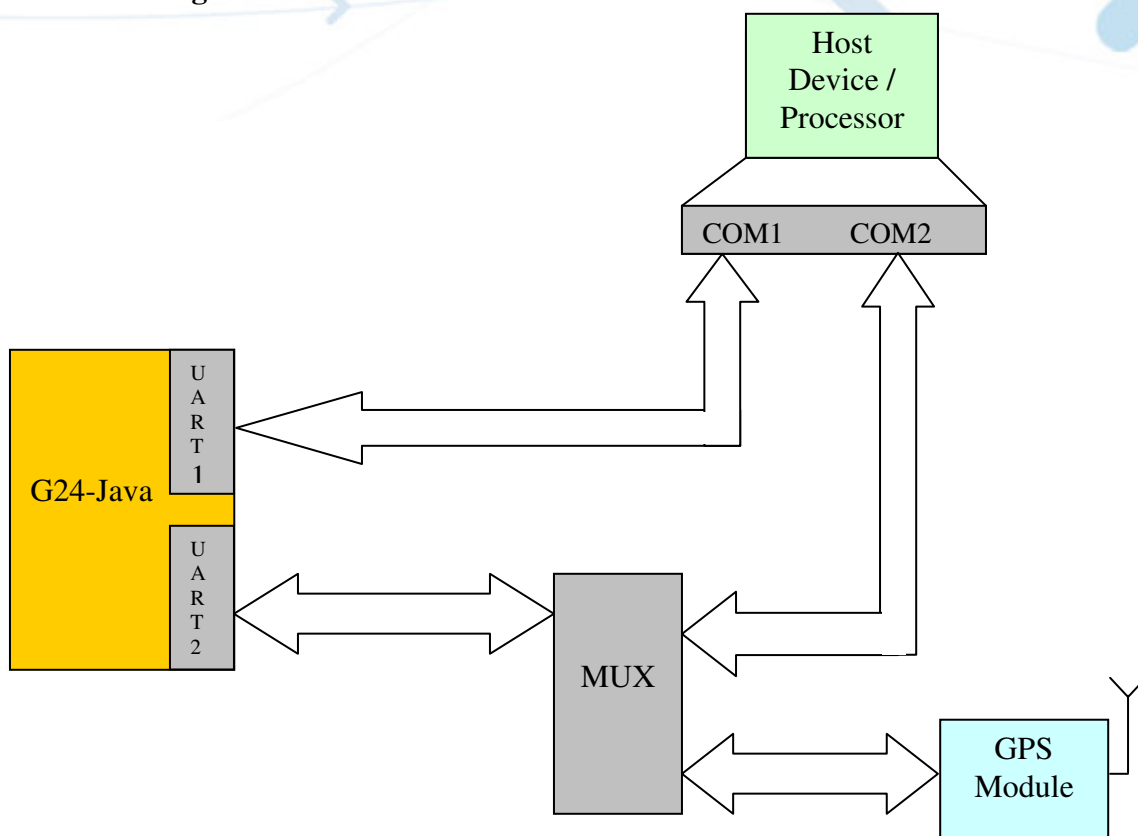


Figure 2 GPS Module Reference Design Block Diagram

This block diagram shows the communication options between the host device, G24-Java and the GPS module. As mentioned above, there are 4 communication options as follow:

1. **Host Device – GPS Module** - GPS module is controlled by Host Device
2. **G24-Java (UART2) – GPS Module** – GPS module is controlled by G24 -Java
3. **G24-Java (UART2) – PC** – For MIDlet loading
4. **G24-Java (UART1) – Host Device** – G24 is controlled by Host Device

Notes:

- The GPS Module supplies DC voltage to the active antenna.
- UART1 and UART2 can work simultaneously
- The MUX block contain two MUX components which are controlled by :MUX_SEL1 & MUX_SEL2.

3.4 Configuration

In order to operate and configure the reference design board, the following guidelines need to be taken into consideration:

3.4.1 Communication Control:

There are 2 jumpers that route and control the UART communication:

- Jumper P10 – MUX_SEL1
- Jumper P11 – MUX_SEL2

MUX_SEL1 and MUX_SEL2 are connected to G24 GPIO1 and G24 GPIO2 respectively to implement the selection in SW instead of using jumpers.

Use the table below for jumpers configuration.

MUX_SEL1 (Jumper P10)	MUX_SEL2 (Jumper P11)	PATH
PLACED	PLACED	Forbidden condition
PLACED	NOT PLACED	G24-Java (UART2) – GPS Module
NOT PLACED	PLACED	Host Device (Processor) – GPS Module
NOT PALCED	NOT PLACED	G24-Java (UART2) – PC

Table 1: MUX_SELECT

3.4.2 MIDlet Control:

- Jumper P1 – GPIO8 = “0” (jumper not placed), remove the jumper in order to run MIDlet
 - Jumper P1 – GPIO8 = “1” (jumper placed), place the jumper in order to hold Java MIDlet
- See chapter 5 for more details.

3.4.3 Switches:

- Switch S1 - G24 module on/off.
- Switch S5 - GPS manual reset

4. Performance Testing using SiRFOncore Application

While GPS Module is controlled by the host device, one can use **SiRFOncore** application (by **SiRF Technology**) in order to perform tests.

The SiRFOncore application and Interface Control Drawing (ICD) document are available on MOTODEV.com

Follow the instructions below in order to use SiRFOncore for performing the GPS RF tests.

4.1 Turning ON the GPS

1. Configure jumpers for **Host Device – GPS Module** communication path (only jumper P11 should be placed) - (as shown in figure 3)
2. Connect RS232 cable to UART 2 (J5) and to host device.
3. Connect the G24 to 70 pin connector (P100).
4. Connect the GPS RF connector (P6) placed on the adaptor board either to a GPS RF Simulator or to an external GPS antenna outdoors where you have a line of sight with the sky.
5. Connect the adaptor board to power supply red (+) and black (-) wire to 3.3-4.2 V. D1 Led will turn on.
6. Press ON/OFF key (S1). Led (D2) near G24 will turn on indicating that the G24 has turned on and the communication lines are active.
7. Open SiRFOncore PC application by double-clicking the icon on desktop.
More information about SiRFOncore application is available on: <http://www.sirf.com/>
8. Press on GPS Reset switch to activate the GPS receiver.



Figure 3 “Host Device – GPS Module” Configuration

4.2 Quick Start using SiRFOncore

While opening SiRFOncore application, a message regarding communication port configuration will appear (as shown in figure 4)

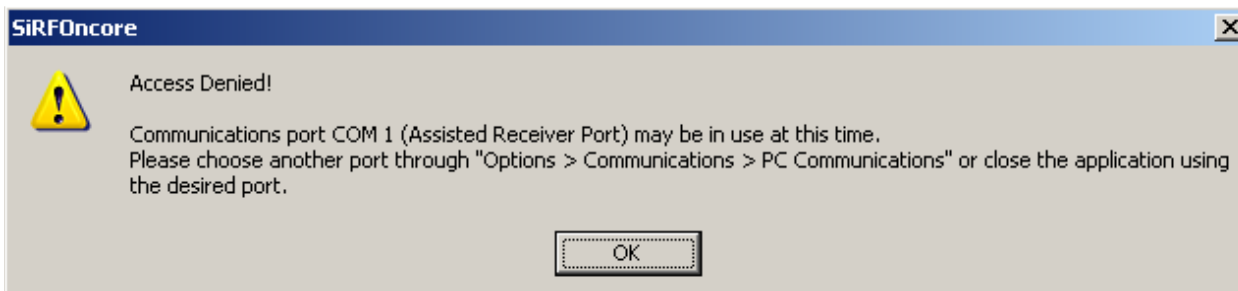


Figure 4 SiRFOncore Communication Note

Follow the below steps in order configure the communication ports properly:

On the menu bar- click on **Options > Communications > PC Communications**.

Press on the OK button.

At the Autonomous section - Set the **Comm Port** to the active port of the PC (as shown in figure 5).

Set the Baud to 19200.

Press on the OK button.

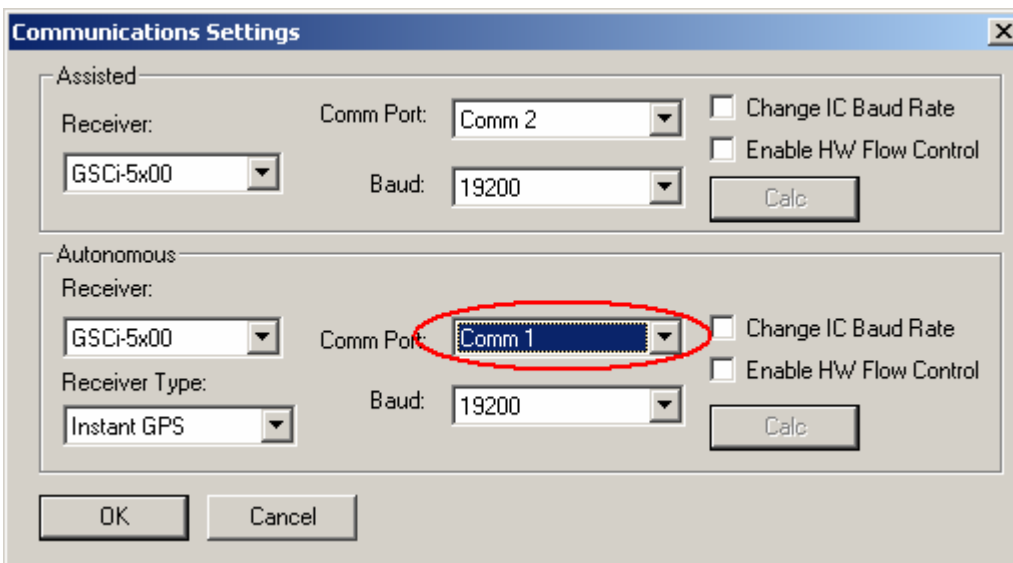


Figure 5 Communication Port Setting

Step A

Host Device to GPS Module Communication Test

After loading the SiRFOncore application Click on “ID=” button, “Receiver ID Dialog” window will open (see figure 6) meaning communication between Host Device to GPS module is OK.

Click the “Close” button in the “Receiver ID Dialog” window

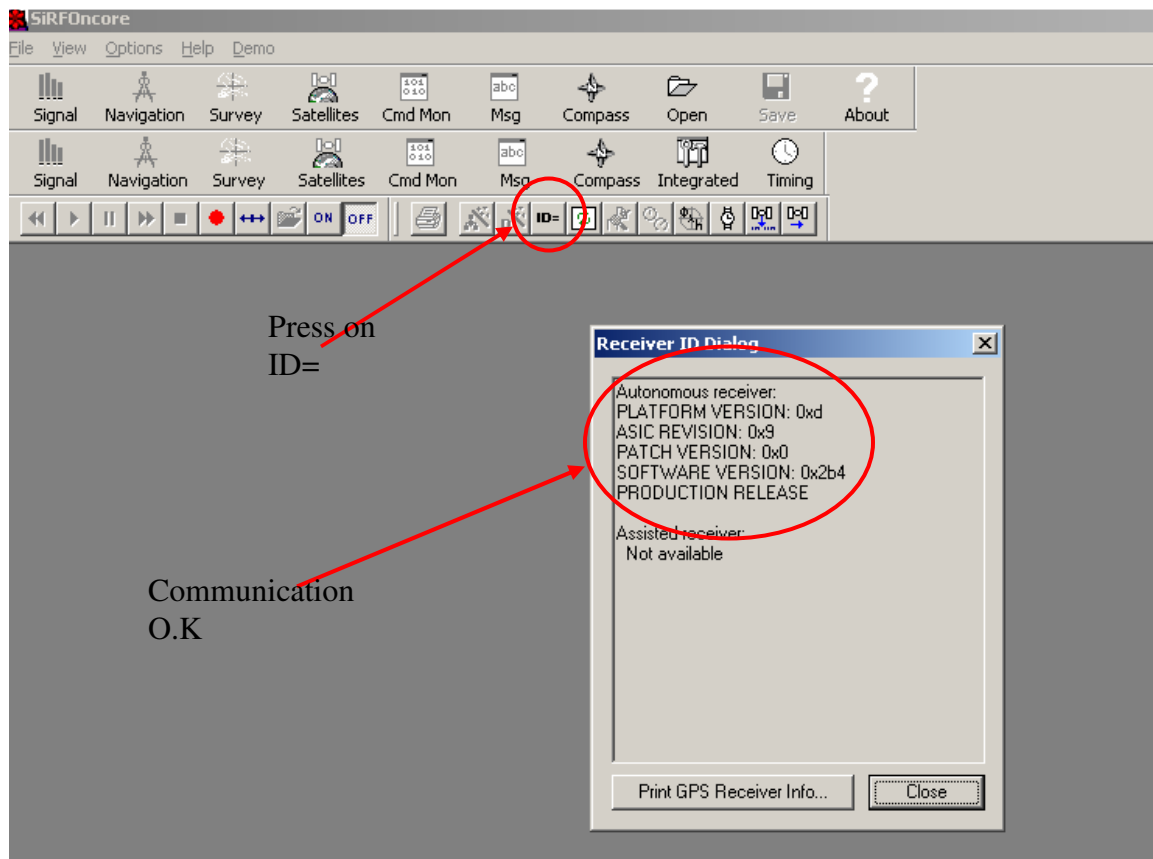


Figure 6 SiRFOncore “ID=” button and “Receiver ID Dialog” window

Step B

Preparation for RF Test

1. Click on “**Signal**” button (as shown in figure 7)
2. Click on “**Navigation**” button (as shown in figure 7)
3. Click on “**Window**” and choose “**Tile**”
4. Connect the GPS RF connector placed on the adaptor board either to a GPS RF Simulator or to an external GPS antenna outdoors where you have a line of sight with the sky.

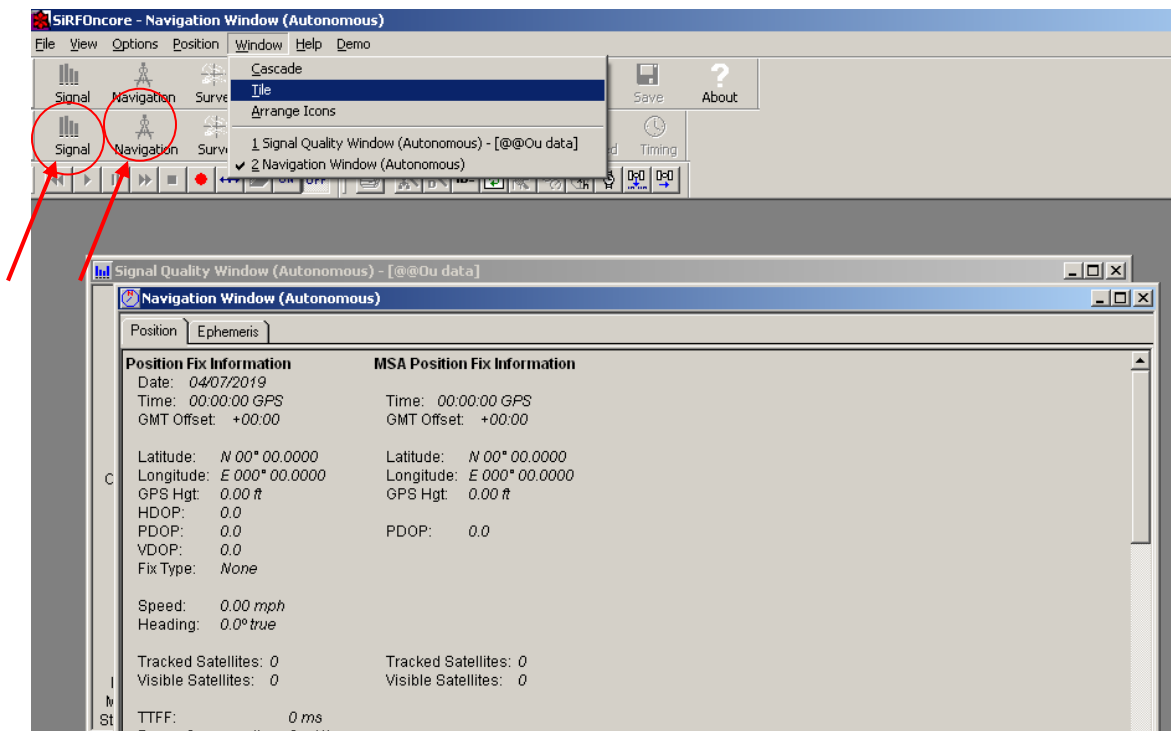


Figure 7 SiRFOncore Open Windows

Step C

GPS Module Receiver Operation

1. Click on “**Options**”
2. Click on “**Execute Script File**” - (see figure 8)
3. At “**Autonomous**” browse and load the script file and click on “**Start**”
The SiRFOncore GPS script file is available on MOTODEV.com
4. When it finishes loading click on “**OK**”. - (see figure 9)

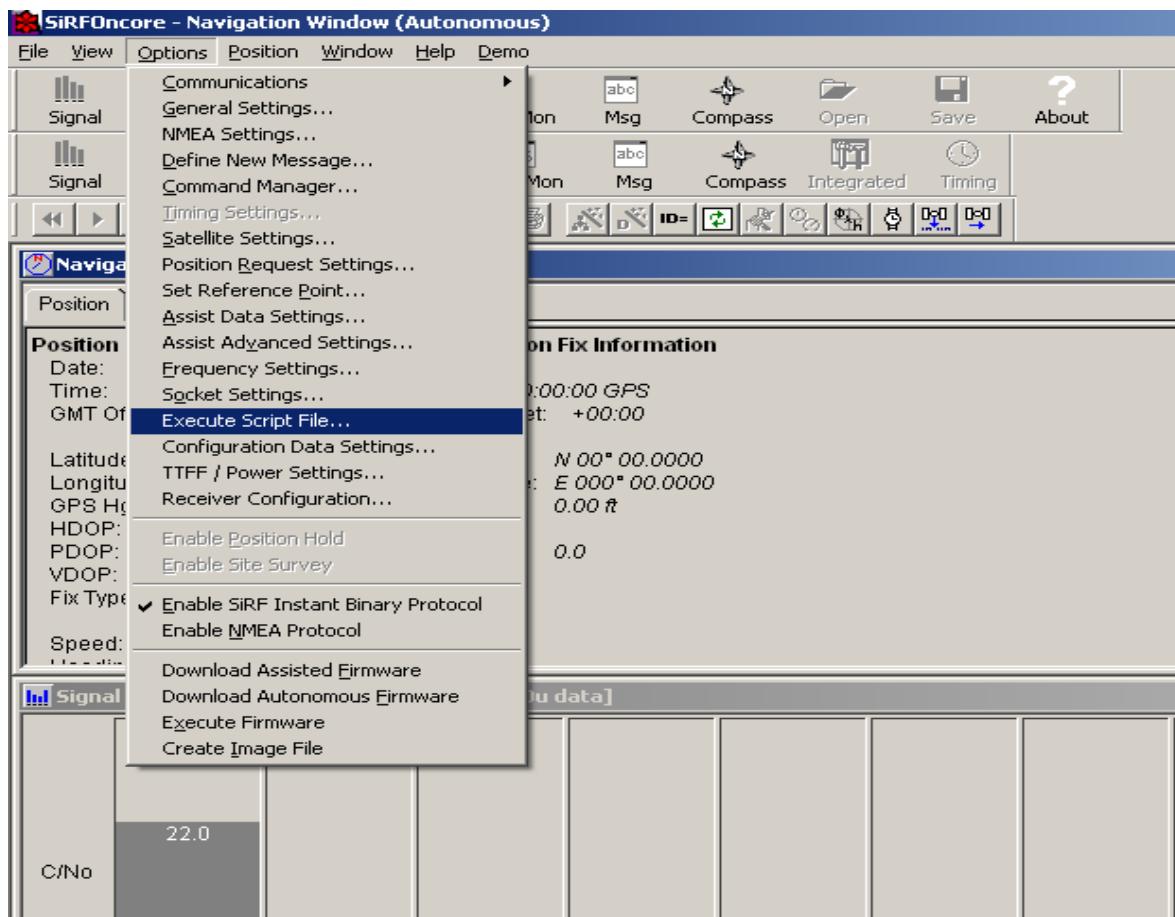


Figure 8 SiRFOncore Execute script file

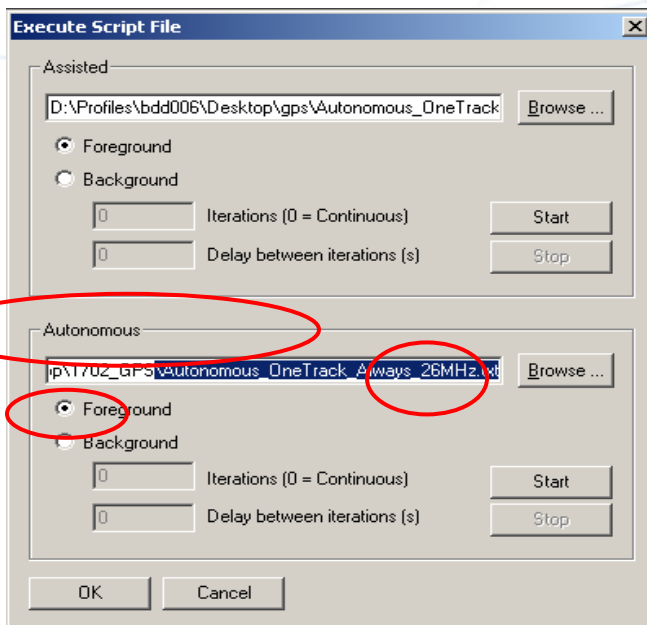


Figure 9 Script File

Step D RF Performance

1. Wait about 40 seconds (depending on RF amplitude) until you get a position location
 2. The location appears in the “**Navigation Window**”.
- For instance: Latitude **N 42deg and 20.16 sec**, Longitude **W071deg and 1.08 sec**. – (see figure 10)
3. An example of “**Signal Quality Window**” also found in figure 10.

Mode:

- 0=Searching
- 1=Detecting
- 2=Acquiring
- 3=Frequency locking
- 4=Bit sync detecting
- 5=Tracking (and decoding data > -142 dBm)
- 6=Time decoding
- 7=Ephemeris decoding
- 8=Available for fix

The position location appears when at least 4 satellites are in mode is 8 (available for fix)

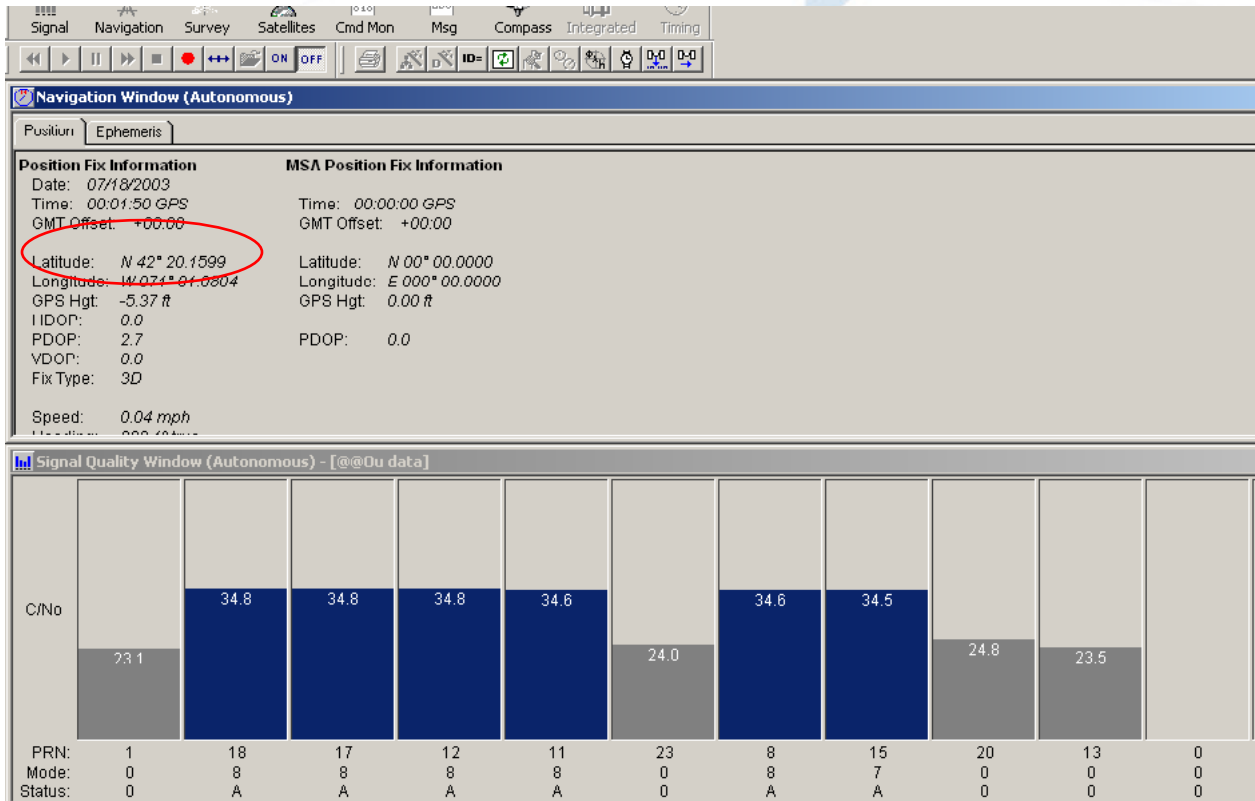


Figure 10 GPS Navigation Window

In this case 6 satellites are active: # 19,17,12,11,8,15.

5 of the satellites are on status 8 and 1 satellite (#15) is on mode 7.

5. GPS module controlled by G24 –Java - Example

This chapter explains how to get Location data from the G24-Java using a Java MIDlet.

5.1 Configuration

Prior to start, make sure G24 flash version is *G24_G_0C.11.A8* or succeser

The GPS MIDlet and the G24 KJAVA User's Guide are available on MOTODEV.com

1. Configure jumpers for **G24-Java (UART2) – PC** communication – for MIDlet loading. (Jumpers P10 and P11 should be removed)
2. Place jumper P1 in order to set the G24 in Java Tool mode.
3. Connect RS232 cable to UART 1 (J5) and to host device.
4. Connect the G24-Java to 70 pin connector (P100).
5. Connect the GPS RF connector (P6) placed on the adaptor board either to a GPS RF Simulator or to an external GPS antenna outdoors where you have a line of sight with the sky.
6. Connect the adaptor board to power supply: red (+) and black (-) wire to 3.3-4.2 V.
7. D1 Led will turn on.
8. Press ON/OFF key (S1). Led (D2) near G24-Java will turn on indicating that the G24-Java has turned on and the communication lines are active.
9. Press on GPS Reset switch to activate the GPS receiver.
10. Connect RS232 cable to UART 2 and to PC.
11. Download the MIDlet to the G24-Java using a standard MIDlet loading application (MIDway or similar). Flow control of selected PC serial port must be set to "None". More information about MIDlet download is available on **G24 KJAVA User's Guide** document, section 3.2.6.
12. In the MIDlet loading application: Direct the STDOUT to UART1.

13. Configure jumpers for **G24-Java – GPS Module** communication path (only jumper P10 should be placed) – as shown in figure 11.
14. Connect RS232 cable to UART 1 (J1) and to PC.

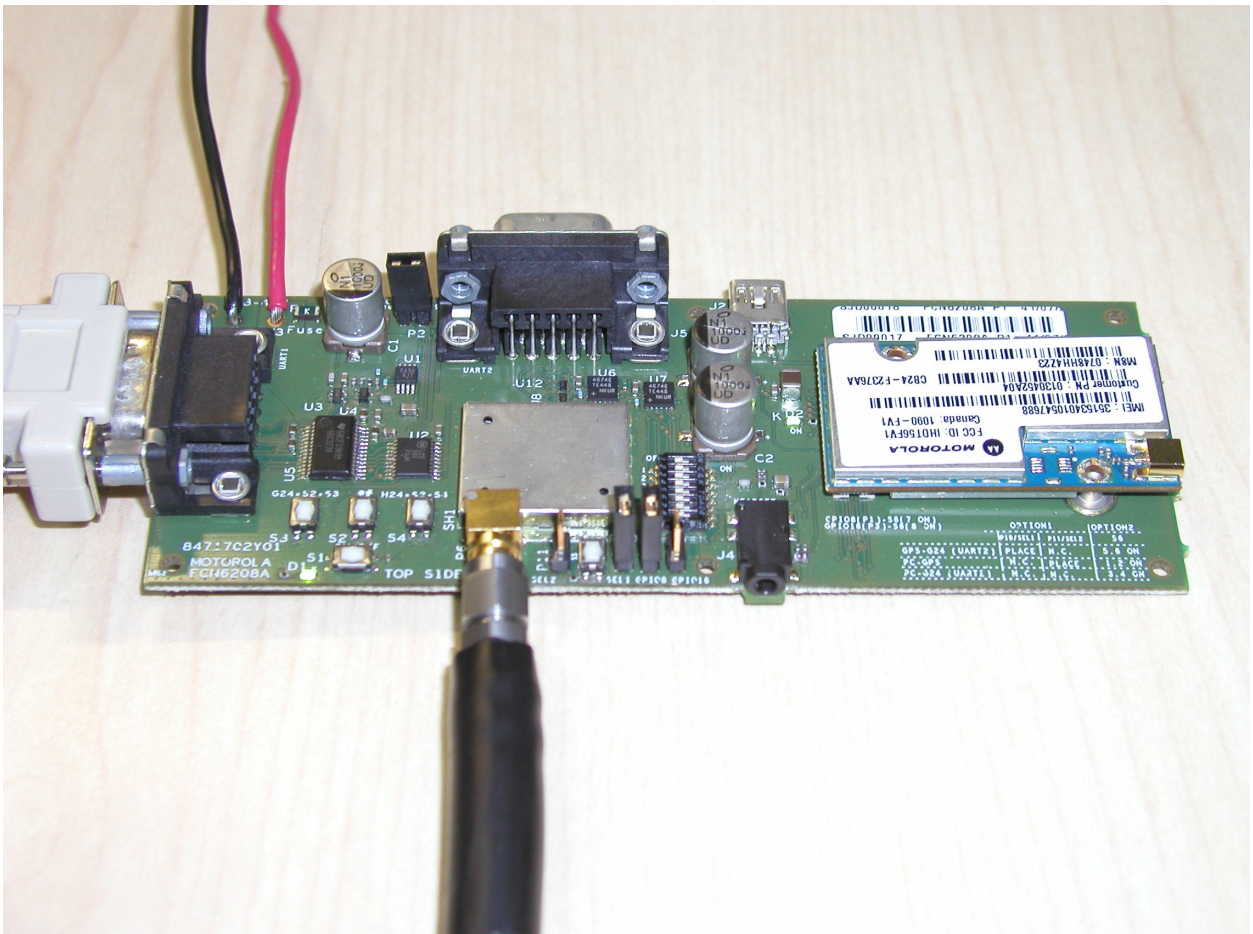


Figure 11 “G24-Java – GPS Module” Configuration

15. Open a PC “**Hyper Terminal**” program.
16. Configure Hyper Terminal with selected COM port, Baud rate 19200, 8 Data bits, None Parity, 1 Stop bit and None Flow Control. – (see figure 12)

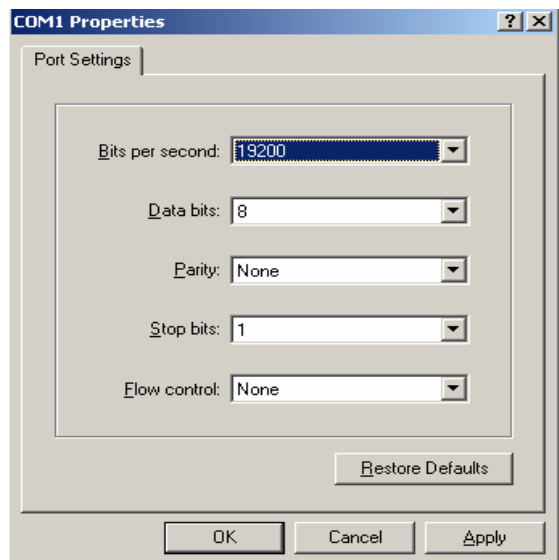


Figure 12 Hyper Terminal Configuration

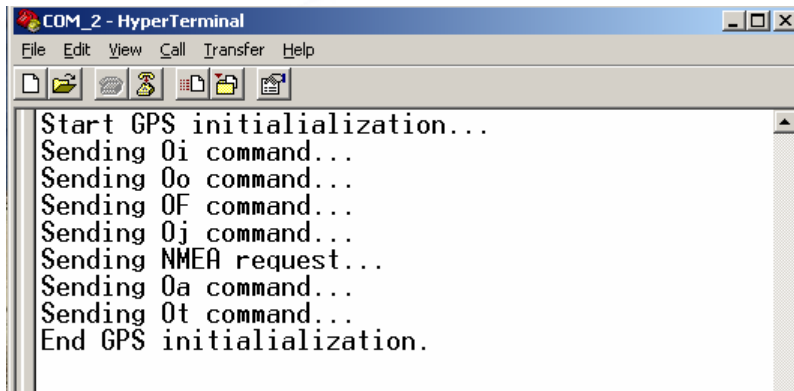
17. Remove jumper from P1 in order to run Java MIDlet.

The MIDlet initializes the GPS (sending appropriate commands to GPS module) in order to receive NMEA messages every 2 seconds.

The MIDlet is using Location APIs of the G24 program in order to get NMEA from GPS and output Location data (longitude, latitude, altitude, speed etc.) on Hyper Terminal.

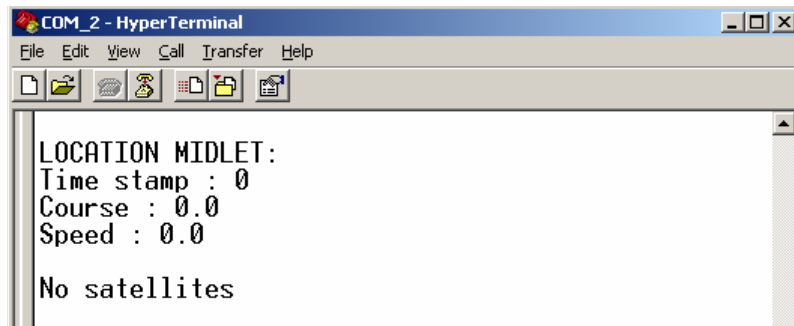
5.2 Acquiring Results

- MIDlet sends Initialization commands to GPS- (as shown in figure 13).
- MIDlet receives Location data - Satellites not found- (as shown in figure 14).
- MIDlet receives Location data - Satellites found – (as shown in figure 15).



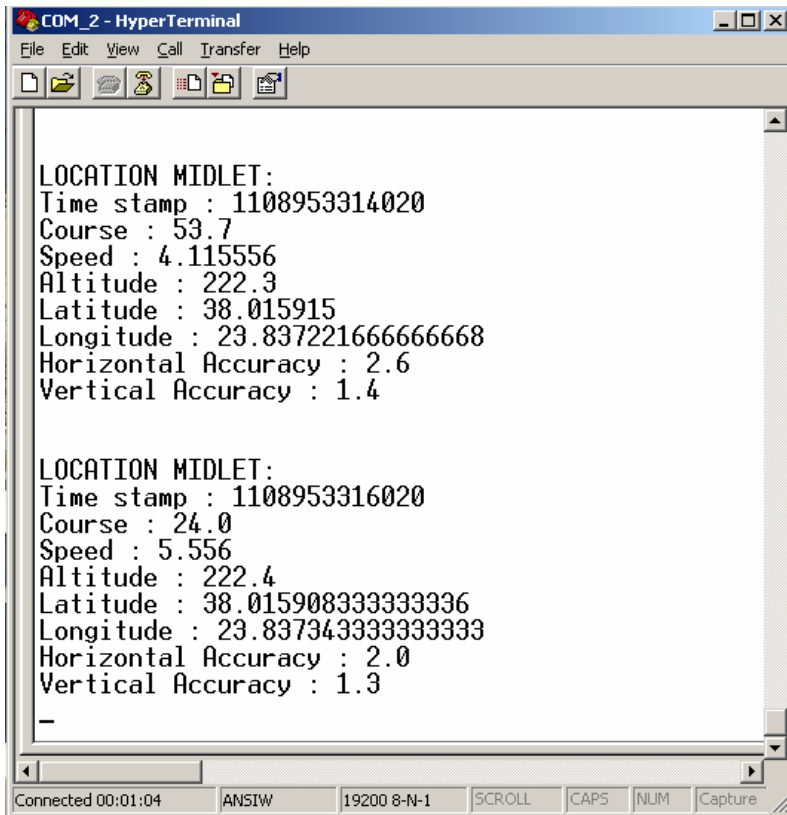
```
COM_2 - HyperTerminal
File Edit View Call Transfer Help
Start GPS initialialization...
Sending 0i command...
Sending 0o command...
Sending 0f command...
Sending 0j command...
Sending NMEA request...
Sending 0a command...
Sending 0t command...
End GPS initialialization.
```

Figure 13 MIDlet Initialize GPS



```
COM_2 - HyperTerminal
File Edit View Call Transfer Help
LOCATION MIDLET:
Time stamp : 0
Course : 0.0
Speed : 0.0
No satellites
```

Figure 14 MIDlet gets location data - Satellites not found



```
COM_2 - HyperTerminal
File Edit View Call Transfer Help

LOCATION MIDLET:
Time stamp : 1108953314020
Course : 53.7
Speed : 4.115556
Altitude : 222.3
Latitude : 38.015915
Longitude : 23.837221666666668
Horizontal Accuracy : 2.6
Vertical Accuracy : 1.4

LOCATION MIDLET:
Time stamp : 1108953316020
Course : 24.0
Speed : 5.556
Altitude : 222.4
Latitude : 38.015908333333336
Longitude : 23.837343333333333
Horizontal Accuracy : 2.0
Vertical Accuracy : 1.3
-

Connected 00:01:04  ANSIW  19200 8-N-1  SCROLL  CAPS  NUM  Capture
```

Figure 15 MIDlet gets Location data - Satellites found

6. GPS Module Design and Layout Recommendations

The design and layout recommendations are for applications using cellular technology as well as GPS. The GPS Module reference design board is designed to work in a cellular environment using an external active antenna.

The GPS Module reference design board makes use of GPS Module (LGA 8.6x8.6x1.55mm) based on SIRF GSCi-5000.

The GPS receiver RF line-up includes 5dB attenuator, saw filter and a second 5dB attenuator (between the RF connector and the GPS module) in order to gain isolation of cellular power on adjacent GPS frequencies.

Increasing cellular to GPS isolation enables us to place the cellular antenna relatively close to the GPS antenna causing a minimal degradation in GPS performance.

The external antenna supplied with the GPS Module Reference Design board is a **Cirocomm** 0300130033A0800

External Antenna specifications:

- Frequency Range $1575.42 \pm 1.023\text{MHz}$
- Gain At 90° : $30 \pm 4.5\text{dBi}$ – Max cable loss 1.2dB/m
Mounted on 60mm*60mm ground plane
- Output Impedance 50Ω
- VSWR 2.0 Max

Cirocomm external antenna data sheet is available on MOTODEV.com

6.1 Front End Configuration

Examine 3 cases:

Case A – RF input pin of the GPS module connected directly to a passive antenna (ignoring the antenna loss).

Case B – RF input pin of the GPS module connected directly to an external active antenna with antenna gain - (as supplied with the evaluation kit).

Case C - RF input pin of the GPS module connected to 5dB ATT, SAW filter (SX-B277H-HB0S), 5dB ATT and external active antenna **Cirotech** 0300130033A0800.

RF Calculation Table:

Case	Noise Figure [dB]	*OOBR @ 1648MHz [dB]	**OOBR @ 1710MHz [dB]	Total Gain [dB]
Case A	2.16	2.4	-7.6	30.4
Case B	1.54	-4	-24	50.4
Case C	2.18	-29	-54	38.8

Table 2 - FRONT END CONFIGURATION

*OOBR 1648M is Out Of Band Rejection of the 2nd GSM 824 MHz harmonic spur.

**OOBR 1710M is the Out Of Band Rejection of fundamental carrier of DCS band.

Recommendations:

Both frequencies are very close to the GPS frequency 1575.42 and special care should be taken in order to reject those frequencies.

Case A – Spur in 1648MHz will be increased by the GPS Module LNA.
This is not recommended if cellular antenna is placed relatively near to the GPS antenna.

Case B – Minimal cellular spur rejection and the best case sensitivity performance will be achieved.

Case C – Small degradation in sensitivity ~0.6dB with a better spur rejection is achieved.

In the GPS Module reference design board CASE C is implemented.

6.2 RF Line-up Schematic

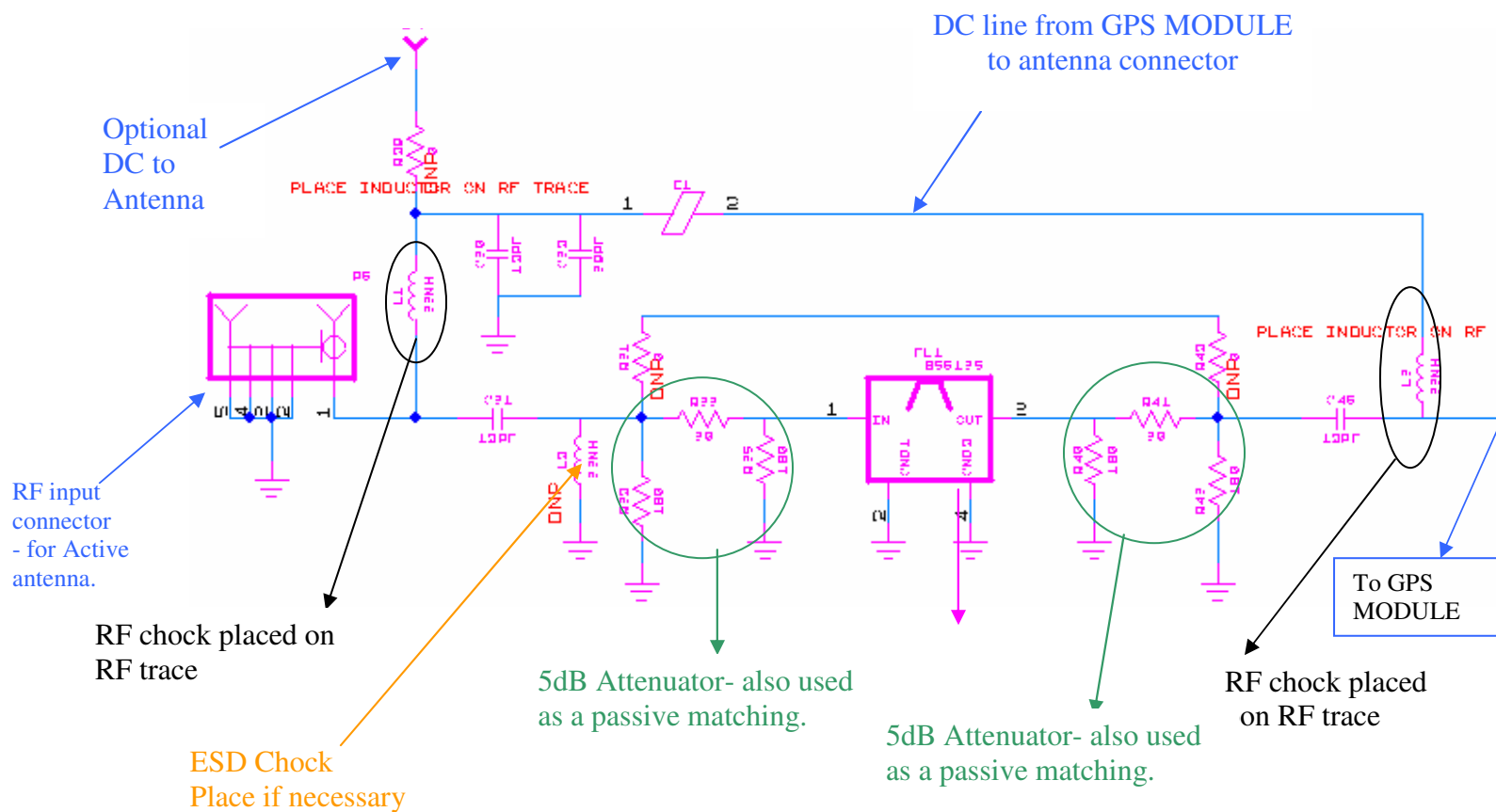


Figure 16 GPS RF Line-up Schematic

6.3 GPS Module Layout Description

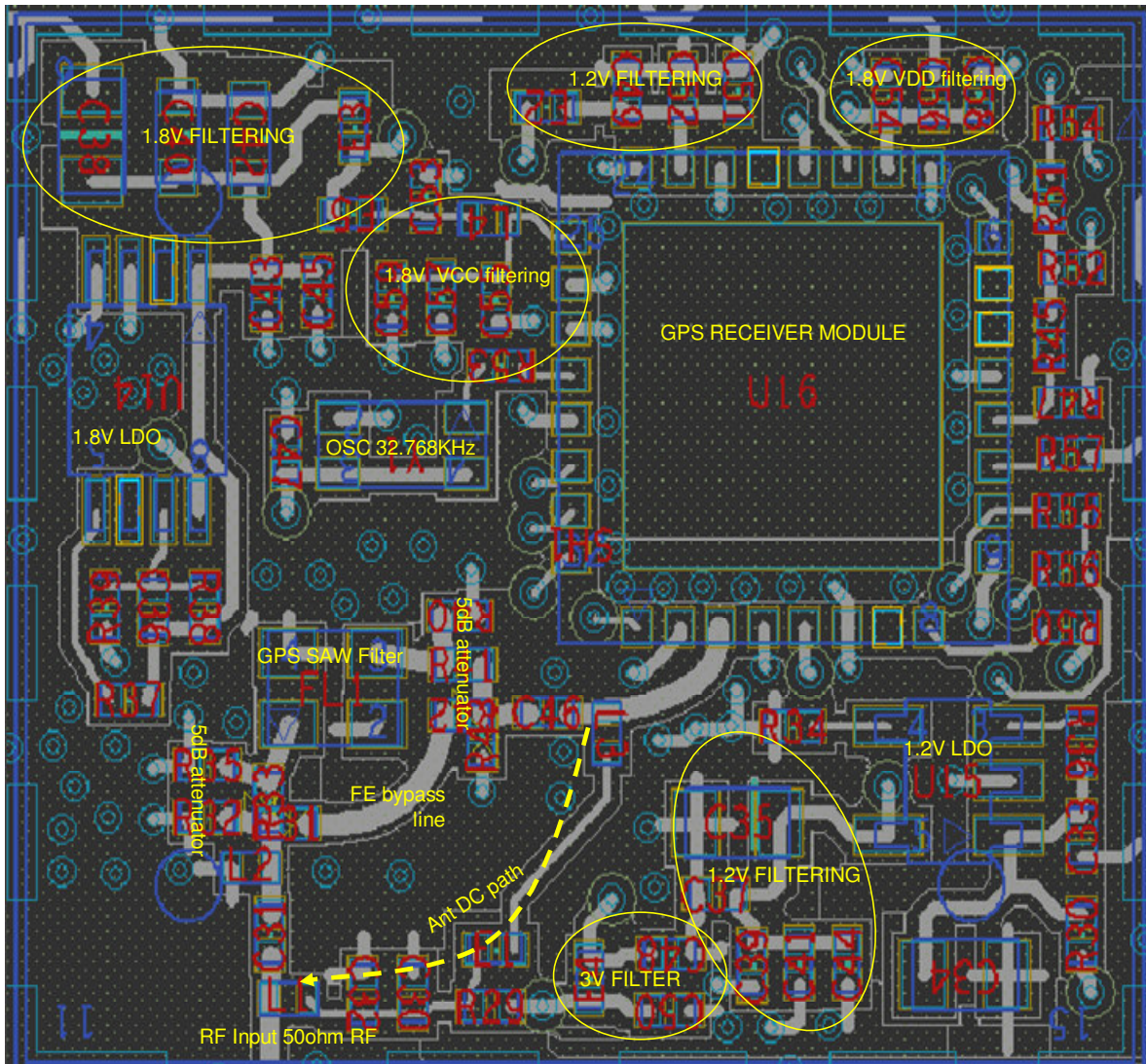


Figure 17 GPS CIRCUIT LAYOUT

6.4 Layout Guidelines

1. The GPS Module RF input trace should be matched to 50 Ohm. If using an active antenna it is recommended to use a strip line shielded with GND vias.
2. There should be a solid ground plane beneath the GPS module.
3. There are bypass capacitors inside the GPS module. Bypass capacitors (recommended values are shown in the RF schematics) should be added near the voltage input pins of the GPS module.
4. The LDO for 1.2V and 1.8V should have small ripple rejection and a good load transient response for 1.2V and 1.8V (for recommended LDO see the schematics reference design).
5. Place the 32 KHz oscillator near the GPS MODULE CLK_32K input pin.
6. Do not directly connect the VCC lines directly to the VDD_I/O lines.
7. See RF and Baseband Schematics for reference components and connectivity.

Note:

In the schematics: DNP – Do Not Place

6.5 GPS Module Reference Design Board Schematics

The GPS Module Reference Design Board RF and BaseBand (BB) Schematics RF are available on MOTODEV.com