Data Sheet / GR-701

u-blox 7

Easy-to-Use

Ultra-High Performance

GPS/QZSS or GLONASS Receiver

RoHS
Compliant

Version 1.2

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Revision History

Ver.	Date	Description
1.0	Mar. 25th, 2015	First release
1.1	July 3rd, 2015	Dimension update
1.2	Sep. 29th, 2016	Update for support web page

Contents

1 Introduction

1.1 Overview

NaviSys GR-701 is an ultra-high performance, easy-to-use GNSS receiver designed with u-blox's latest 7th generation single chip – UBX-G7020-KT.

Its high performance enables the rapid deployment of AVL, timing, and other location based applications. It supports different electrical interfaces such as USB, RS232, UART TTL etc. The connector interface and cable length could be customized based on MOQ.

The receiver reports using version 2.3 of the NMEA0183 standard referenced to the WGS-84 datum.

1.2 Main Features

Our expert design exhibits the full performance of u-blox 7 chip.

- Full implementation of ultra-high performance u-blox 7 single chip architecture
- High tracking sensitivity of -162 dBm!
- GNSS support : either GPS/QZSS (default) or GLONASS
- Up to 10Hz update rate (default 1Hz)
- SBAS (WAAS, EGNOS, MSAS) support
- RTCM 2.3 support
- Easy deployment
- Built-in 25x25x4 (mm) patch antenna
- Built-in backup power for faster position fix.
- External backup power option via I/O pin is available for special application of high working temperature.
- USB/UART TTL/RS232 interface support
- PPS support for timing application, including PPS over USB
- Compatible with GPSD
- Low power consumption of 37mA for average tracking
- Hardware power saving control pin allowing power on/off GPS via GPIO
- OMA SUPL compliant A-GPS support

- Windows location sensor support
- Linux/Android support
- **IPX7** Waterproof
- LED for position fix indication
- Built-in magnet
- Fully EMI shielded
- Industrial operating temperature range: **-40 ~ 85**℃

1.3 Receiver Specifications

Features	Specifications[!]
GPS/QZSS receiver type	56-channel u-blox 7 engine GPS & QZSS:L1 C/A,1575.42MHz, GLONASS:L1OF,1598.0625~1605.375MHz SBAS: WAAS, EGNOS, MSAS, L1 frequency, C/A code
Horizontal Position Accuracy	Autonomous:2.5m (GPS), 4m (GLONASS) SBAS: 2.0m (GPS) (CEP, 50%, 24hr static, -130dBm, 6+ SVs)
Velocity Accuracy	<0.1 m/s (speed) <0.5° (heading) (50%@30m/s)
Accuracy of PPS Signal	30ns (RMS) or <60 ns (99%) for GPS 50ns (RMS) or <100 ns (99%) for GLONASS 0.5ms for PPS over USB
TTFF (Time to First Fix) (50%, -130dBm, autonomous)	Hot Start: 1sec (GPS), 1sec (GLONASS) Warm Start: 28sec (GPS), 25sec (GLONASS) Cold Start: 29sec (GPS), 30sec (GLONASS)
Sensitivity dBm (Autonomous)	Acquisition: -148 (GPS), -140 (GLONASS) Tracking: -162 (GPS), -158 (GLONASS)
Measurement data output	Update rate: 1 Hz (default), up to 10 Hz by enabling command NMEA output protocol: Ver. 2.3 (compatible to 3.0) UART default baud rate: 9600 bps, (N-8-1) Datum: WGS-84 Default: GGA, GLL, GSA, GSV, RMC, VTG, TXT
Max. Altitude	< 50,000 m
Max. Velocity	< 1,852 km/hr
SBAS Support	WAAS, EGNOS, MSAS
Dynamics	< 4g
Power consumption	37 mA / average tracking (9 SVs) 13.5uA / backup power (module disabled)
Power supply	3.3 ~ 5.5 V

Dimension	40 (W) x 45 (L) x 16 (H) (mm)
Operating temperature	-40°C ~ +85°C (-20~60℃ for backup battery)
Storage temperature	-40°C ~ +85°C (-40~60℃ for backup battery)

[1]Note: Data is from chip vendor.

1.4 Protocols

The NMEA protocol is supported via serial UART (RX/TX), RS232 or USB (DM/DP) I/O port. The default supported protocol is NMEA.

1. Serial communication channel – UART/RS232
    i. No parity, 8-data bit, 1-stop bit (N-8-1)
    ii. 9600 bps.
2. NMEA 0183 Version 2.3 ASCII output
    i. Default GGA, GSA, GSV, GLL, RMC, VTG and TXT
3. u-blox binary protocol (UBX)
4. RTCM input
    i. According to Differential-GPS data according RTCM 10402.3: "RECOMMENDED STANDARDS FOR DIFFERENTIAL GNSS".
    ii. Supported message types: 1,2,3,9
        1. Differential GPS Corrections
        2. Delta Differential GPS Corrections
        3. GPS Reference Station Parameters
        4. GPS Partial Correction Set
    iii. RTCM cannot be used together with SBAS.

1.5 1PPS

The GPS 1PPS is a time pulse delivered at the top of each GPS second with accuracy of 30ns (RMS) or 60ns (99%). This signal allows devices all over the world to be accurately synchronized to a common time base.

GR-701R/GR-701T provides 1PPS on pin 5 of the Mini-DIN connector.

GR-701W expresses the 1PPS signal over the USB interface as simulated DCD (Data Carrier Detect) handshake notifications. Time accuracy of these notifications is limited by the USB polling interval, and will typically be 0.5ms. Interpretation of these notifications requires support in your operating system's device driver for the Prolific PL-2303 USB; Linux 2.6 is

known good for this purpose.

Leap second – Due to the synchronization between atomic clocks and earth rotation, there is leap second adjustments every a few years. Such kind of adjustment would be calibrated before chip release. There might be multiple leap second adjustments after chip release. The chip will adjust such kind of leap seconds after it acquires accurate clock and leap second information.

To know if leap second has been calibrated, one can send following binary command to query.

B5 62 01 20 00 00 21 64

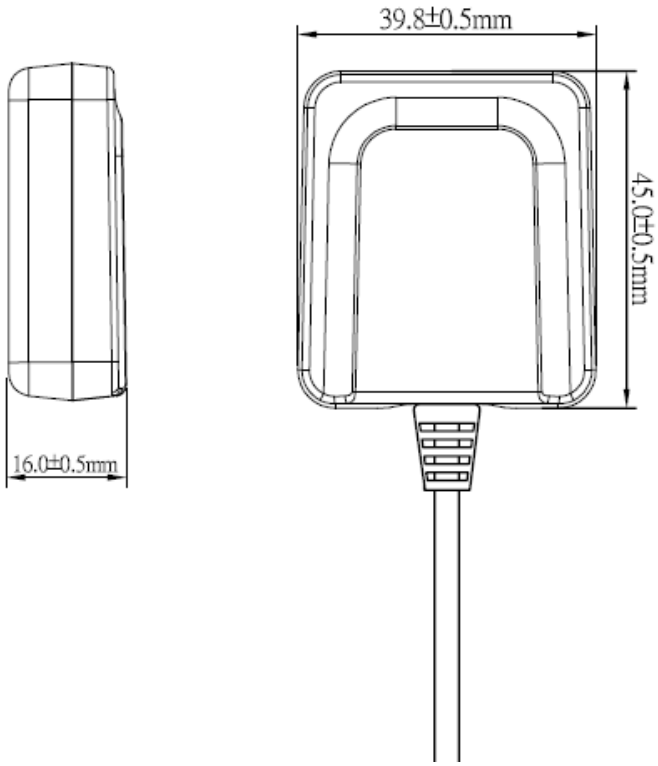
The chip will return binary message similar to following two.

B5 62 01 20 10 00 80 09 47 07 87 6A 06 00 22 07 0F 03 0C 00 00 00 46 50
B5 62 01 20 10 00 60 DB 56 07 AC 5F FF FF 22 07 10 07 09 00 00 00 18 45

Check the value of byte 18 which is marked in red, if the value is 07, the GPS time is correct. Otherwise (e.g. 3, 1, 0), the GPS time is still not correct.

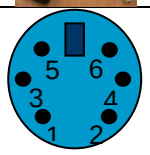
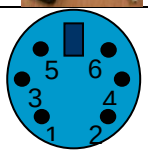
2 Hardware Interface

2.1 Dimension



The dimension of GR-701 is 40 mm (W) x 45 mm (L) x 16 mm (H) as shown above.

2.2 I/O Connectors and Pin Assignment

	GR-701T	GR-701R	GR-701U/W
			
			
Pin	Mini-Din 6-pin PS/2 Male Plug	Mini-Din 6-pin PS/2 Male Plug	USB A type Male Plug
1	GND	GND	VDD 5V
2	VCC	VCC	D-
3	TXD-TTL	TX-RS232	D+
4	RXD-TTL	RX-RS232	GND
5	PPS	$PPS	-
6	PWR_CTRL	PWR_CTRL	-

$: RS232 signal level for longer distance transmission

Pin	Name	Function	I/O
1	GND/VDD	Ground / USB 5 VDC power supply	Input
2	VCC/D-	Power supply (3.3 ~ 5.5 VDC) / USB D-	Input / IO
3	TX/D+	Serial data output (from GPS) / USB D+	Output / IO
4	RX/GND	Serial data input (into GPS) / USB ground	Input
5	PPS	1PPS signal for precise GPS time synchronization	Output
6	PWR_CTRL	Power control; High/floating: ON, Low: OFF	Input

Power Saving

GR-701 supports the hardware power saving mechanism. To control the power of GR-701, connect the **PWR_CTRL** pin to a GPIO of a micro-processor. To cut off the power of GR-701 (VCC is always connected to power source), just pull the PWR_CTRL pin low (in this case, GR-701 only keeps power of RTC and RAM). During normal run, pull it high or leave it floating (in this case, GR-701 is fully powered).

2.3 Cable Length, Dimension and LED

The default cable length for different models is shown below.

Cable Length	1.5m for GR-701U 3m for GR-701R <1m for GR-701T

An embedded LED is used to indicate the GPS position fixing status as following:

LED always ON: Position is not fixed, under fixing

LED Blinking: Position is fixed

Note.

Customization options: **cable length** (0.1~15m), **connector type** (DB9/25, RJ11/45, MicroFit, SM-4Y, etc), **higher voltage input** (12/24V etc).

3 Software Interface

GR-701 supports both NMEA text messages and UBX binary messages. For the UBX binary messages, please refer to u-blox Receiver Description Protocol Spec. In this section, the NMEA output messages are discussed.

3.1 NMEA Output Messages

To distinguish GLONASS fix from GPS fix, new talker ID (GL) is used.

- Talker ID is 'GP' if worked in GPS mode
- Talker ID is 'GL' if worked in GLONASS mode

The NMEA-0183 Output Messages are shown as below:

NMEA Record	Descriptions
GxGGA	Global positioning system fixed data: time, position, fixed type
GxGLL	Geographic position: latitude, longitude, UTC time of position fix and status
GxGSA	GPS receiver operating mode, active satellites, and DOP values
GxGSV	GNSS satellites in view: ID number, elevation, azimuth, and SNR values
GxRMC	Recommended minimum specific GNSS data: time, date, position, course, speed
GxVTG	Course over ground and ground speed
GxTXT	u-blox message

The GR-701 adopts interface protocol of National Marine Electronics Association's NMEA-0183 Version 2.3 interface specification. GR-701 supports 7 types of NMEA sentences (GxGGA, GxGLL, GxGSA, GxGSV, GxRMC, GxVTG, and GxTXT).

The default output sentences are GPGGA, GPGSA, GPGSV, GPRMC, GPVTG and GPGLL.

GPS message examples:

$GPRMC,065500.00,A,2447.65027,N,12100.78318,E,15.869,189.32,051109,,,D*57

$GPVTG,189.32,T,,M,15.869,N,29.405,K,D*30

$GPGGA,065500.00,2447.65027,N,12100.78318,E,2,12,0.91,69.8,M,16.3,M,,*65

$GPGSA,A,3,20,02,23,13,50,42,04,11,17,28,32,08,1.53,0.91,1.22*0D

$GPGSV,4,1,13,02,10,252,26,04,39,268,40,08,09,197,41,11,17,058,32*7B

$GPGSV,4,2,13,13,06,144,23,17,50,345,43,20,45,056,44,23,11,109,37*72

$GPGSV,4,3,13,27,02,301,,28,73,194,39,32,20,043,38,42,54,140,34*7B

$GPGSV,4,4,13,50,51,133,33*4B

$GPGLL,2447.65027,N,12100.78318,E,065500.00,A,D*6E

$GPTXT,01,01,02,u-blox ag - www.u-blox.com*50

GLONASS message examples:

$GLRMC,031809.00,V,,,,,,,050913,,,N*6C

$GLVTG,,,,,,,,,N*2C

$GLGGA,031809.00,,,,,0,04,1.76,,,,,,*4D

$GLGSA,A,1,81,79,77,82,,,,,,,,,4.23,1.76,3.84*1B

$GLGSV,2,1,06,77,26,149,33,78,79,127,,79,39,336,32,81,59,299,35*6F

$GLGSV,2,2,06,82,23,242,33,88,33,020,*6E

$GLGLL,,,,,031809.00,V,N*55

$GLRMC,031810.00,A,2446.42259,N,12100.44836,E,0.265,,050913,,,A*6B

$GLVTG,,T,,M,0.265,N,0.491,K,A*32

$GLGGA,031810.00,2446.42259,N,12100.44836,E,1,05,1.29,133.2,M,16.3,M,,*40

$GLGSA,A,3,81,79,88,77,82,,,,,,,,3.50,1.29,3.26*18

$GLGSV,2,1,06,77,26,149,34,78,79,127,26,79,39,336,33,81,59,299,35*6D

$GLGSV,2,2,06,82,23,242,33,88,33,020,28*64

$GLGLL,2446.42259,N,12100.44836,E,031810.00,A,A*7D

3.2 GxGGA - Global Positioning System Fix Data

- Example

  $GPGGA,065500.00,2447.65027,N,12100.78318,E,2,12,0.91,69.8,M,16.3,M,,*65

- Explanation

Contents	Example	Unit	Explanation
Message ID	$GPGGA		GGA protocol header
UTC Time	065500.00		hhmmss.ss hh: hour, mm: minute, ss: second
Latitude	2447.65027		ddmm.mmmmm dd: degree, mm.mmmmm: minute
North/South	N		N: North Latitude, S: South Latitude
Longitude	12100.78318		dddmm.mmmmm dd: degree, mm.mmmmm: minute

East/West	E		E: East Longitude, W: West Longitude
Position Fix Indicator	2		0: Fix not available or invalid, 1: GPS SPS Mode, fix valid, 2: Differential GPS, SPS Mode, fix valid, 3~5: Not supported, 6: Dead Reckoning Mode, fix valid
Satellites Used	12		Number of satellites used in positioning calculation (0 to 12)
HDOP	0.91		Horizontal Dilution of Precision
MSL Altitude	69.8	meters	
Unit	M		Meters
Geoidal separation	16.3	meters	
Units	M		Meters
Age of Diff. Corr.		second	Null fields when DGPS is not used
Diff. Ref. Station ID			
checksum	*65		
<CR><LF>			End of sentence

3.3 GxGLL - Geographic Position - Latitude / Longitude

- Example

  $GPGLL,2447.65027,N,12100.78318,E,065500.00,A,D*6E

- Explanation

Contents	Example	Unit	Explanation
Message ID	$GPGLL		GLL protocol header
Latitude	2447.65027		ddmm.mmmmm dd: degree, mm.mmmmm: minute
North/South	N		N: North Latitude, S: South Latitude
Longitude	12100.78318		dddmm.mmmmm dd: degree, mm.mmmmm: minute
East/West	E		E: East Longitude, W: West Longitude
UTC Time	065500.00		hhmmss.ss hh: hour, mm: minute, ss: second
Status	A		A: Data valid, V: Data invalid
Mode Indicator	D		A: Autonomous, D: DGPS, E: DR
checksum	*6E		
<CR><LF>			End of sentence

3.4 GxGSA - GNSS DOP and Active Satellites

- Example

  $GPGSA,A,3,20,02,23,13,50,42,04,11,17,28,32,08,1.53,0.91,1.22*0D

- Explanation

Contents	Example	Explanation
Message ID	$GPGSA	GSA protocol header
Mode 1	A	M: Manual—forced to operate in 2D or 3D mode A: 2D Automatic—allowed to automatically switch 2D/3D
Mode 2	3	1: Fix not available 2: 2D (<= 4 Satellites used)

		3: 3D (>= 4 Satellites used)
Satellite used in solution	20	Satellite on Channel 1
Satellite used in solution	02	Satellite on Channel 2
…		Display of quantity used (12 max) If less than 12 SVs are used for navigation, the remaining fields are left empty. If more than 12 SVs are used for navigation, only the IDs of the first 12 are output.
PDOP	1.53	Position Dilution of Precision
HDOP	0.91	Horizontal Dilution of Precision
VDOP	1.22	Vertical Dilution of Precision
checksum	*0D	
<CR><LF>		End of sentence

3.5 GxGSV - GNSS Satellites in View

- Example

  $GPGSV,4,1,13,02,10,252,26,04,39,268,40,08,09,197,41,11,17,058,32*7B

  $GPGSV,4,2,13,13,06,144,23,17,50,345,43,20,45,056,44,23,11,109,37*72

  $GPGSV,4,3,13,27,02,301,,28,73,194,39,32,20,043,38,42,54,140,34*7B

  $GPGSV,4,4,13,50,51,133,33*4B

- Explanation

Contents	Example	Unit	Explanation
Message ID	$GPGSV		GSV protocol header
Number of messages	4		Range 1 to 4
Message number	1		Range 1 to 4
Satellites in view	13		Number of satellites visible from receiver
Satellite ID number	02		Channel 2 (Range 1 to 64) The satellite ID numbers are in the range of 1 to 32 for GPS satellites, and 33 to 64 for SBAS satellites (ID=120-PRN; e.g. SV ID 33 is SBAS PRN 120, 34 is SBAS PRN 121, and so on)
Elevation	10	degrees	Elevation angle of satellite as seen from receiver channel 1 (00 to 90)
Azimuth	252	degrees	Satellite azimuth as seen from receiver channel 1 (000 to 359)
SNR (C/No)	26	dBHz	Received signal level C/No from receiver channel 1 (00 to 99, null when not tracking)
…			
Satellite ID number	11		Channel 4 (Range 1 to 32)
Elevation	17	degrees	Elevation angle of satellite as seen from receiver channel 4 (00 to 90)
Azimuth	058	degrees	Satellite azimuth as seen from receiver channel 4 (000 to 359)
SNR (C/No)	32	dBHz	Received signal level C/No from receiver channel 4 (00 to 99, null when not tracking)
checksum	*71		
<CR><LF>			End of sentence

3.6 GxRMC - Recommended Minimum Specific GNSS Data

- Example

  $GPRMC,065500.00,A,2447.65027,N,12100.78318,E,15.869,189.32,051109,,,D*57

- Explanation

Contents	Example	Unit	Explanation
Message ID	$GPRMC		RMC protocol header
UTC Time	065500.00		hhmmss.ss hh: hour, mm: minute, ss: second
Status	A		A: Data valid, V: Data invalid
Latitude	2447.65027		ddmm.mmmmm dd: degree, mm.mmmmm: minute
North/South	N		N: North Latitude, S: South Latitude
Longitude	12100.78318		dddmm.mmmmm dd: degree, mm.mmmmm: minute
East/West	E		E: East Longitude, W: West Longitude
Speed over ground	15.869	knots	Receiver's speed
Course over ground	189.32	degrees	Receiver's direction of travel Moving clockwise starting at due north
Date	051109		ddmmyy dd: Day, mm: Month, yy: Year
Magnetic variation		degrees	This receiver does not support magnetic declination. All "course over ground" data are geodetic WGS84 directions.
Mode Indicator	D		A: Autonomous M: Manual D: DGPS S: Simulation E: Dead Reckoning N: Data Invalid
checksum	*57		
<CR><LF>			End of sentence

3.7 GxVTG - Course over Ground and Ground Speed

- Example

  $GPVTG,189.32,T,,M,15.869,N,29.405,K,D*30

Explanation

Contents	Example	Unit	Explanation
Message ID	$GPVTG		VTG protocol header
Course over ground	189.32	degrees	Receiver's direction of travel Moving clockwise starting at due north (geodetic WGS84 directions)
Reference	T		True
Course over ground		degrees	Receiver's direction of travel
Reference	M		Magnetic
Speed over ground	15.869	knots	Measured horizontal speed
Unit	N		Knots
Speed over ground	29.405	km/hr	Measured horizontal speed
Unit	K		km/hr
Mode Indicator	D		A: Autonomous, D: DGPS, E: DR
checksum	*30		
<CR><LF>			End of sentence

3.8 GxTXT – Text Transmission

- Example

  $GPTXT,01,01,02,u-blox ag - www.u-blox.com*50

Explanation

Contents	Example	Unit	Explanation
Message ID	$GPTXT		TXT protocol header
Number of messages	01		Total number of messages in this transmission, 01..99
Message number	01		Message number in this transmission, range 01..xx
Message type	02		Text identifier, u-blox GPS receivers specify the type of the message with this number. 00: Error 01: Warning 02: Notice 07: User
Text	u-blox ag - www.u-blox.com		Any ASCII text
Checksum	*50		Checksum
<CR><LF>			End of sentence

3.9 GNSS Switching Commands

Switches between different GNSS systems could be done by u-blox binary commands described below.

Switch to GLONASS

B5 62 06 3E 24 00 00 00 16 04 00 04 FF 00 00 00 00 01 01 01 03 00 00 00 00 01 05 00 03 00 00 00 00 01 06 08 FF 00 01 00 00 01 A4 0D

Switch to GPS+QZSS+SBAS

B5 62 06 3E 24 00 00 00 16 04 00 04 FF 00 01 00 00 01 01 01 03 00 01 00 00 01 05 00 03 00 01 00 00 01 06 08 FF 00 00 00 00 01 A6 45

Responses

ACK (Success): B5 62 05 01 02 00 06 3E 4C 75

NAK (Failure): B5 62 05 00 02 00 06 3E 4B 70

Please note that

- Hexadecimal values under each command are binary data.

- E.g. B5 is one byte. It should NOT be sent as two characters.

- Each command is followed by either an ACK or a NAK response.
  - ACK response: the command has been successfully executed
  - NAK response: the command is not valid and is not accepted
- The switch to alternating satellite system takes time from a few to tens of seconds
  - Typically, the longer it runs, the longer it takes to switch.

Save Configuration

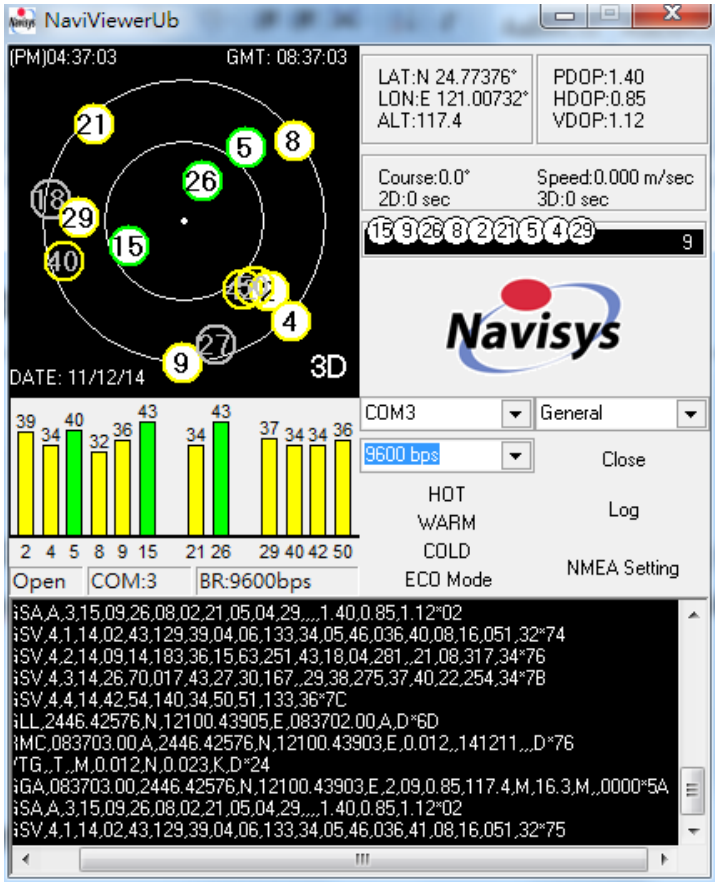
The configuration will disappear if it was not saved and power is OFF. This command will save the configuration to BBR (battery backed RAM) so that the settings will be kept as the backup power is supplied.

B5 62 06 09 0D 00 00 00 00 00 FF FF 00 00 00 00 00 00 03 1D AB

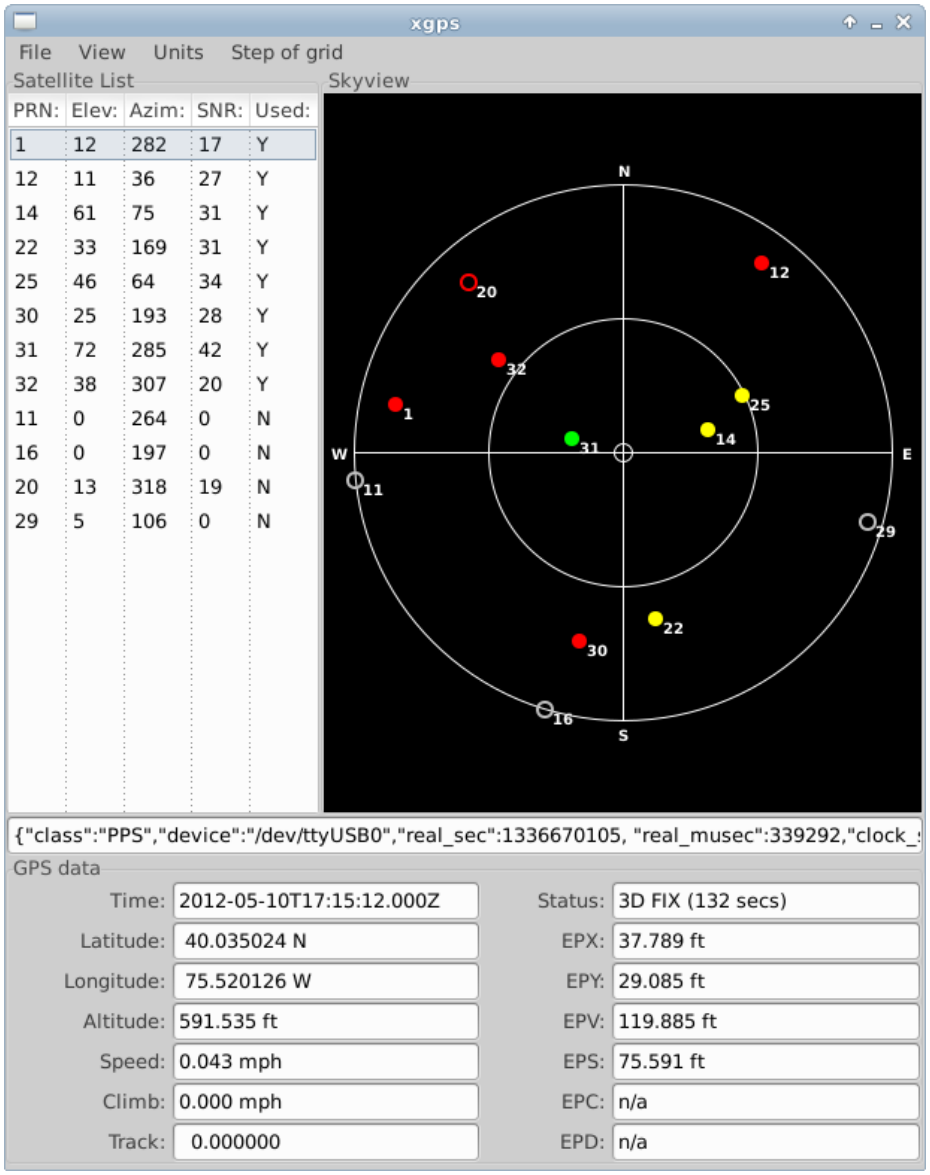
4 Evaluation Information

4.1 Overview

Under Windows, connect the GR-701 to your PC and check its performance using the Navisys GPS viewer tool. You can download the Navisys GPS viewer tool for u-blox from Navisys web site as shown in next section.



Under Linux or *BSD, install GPSD and ensure that the gpsd daemon is running (under Linux, hotplug rules will launch it when you plug the device into a USB port). Then run the xgps or cgps test client.

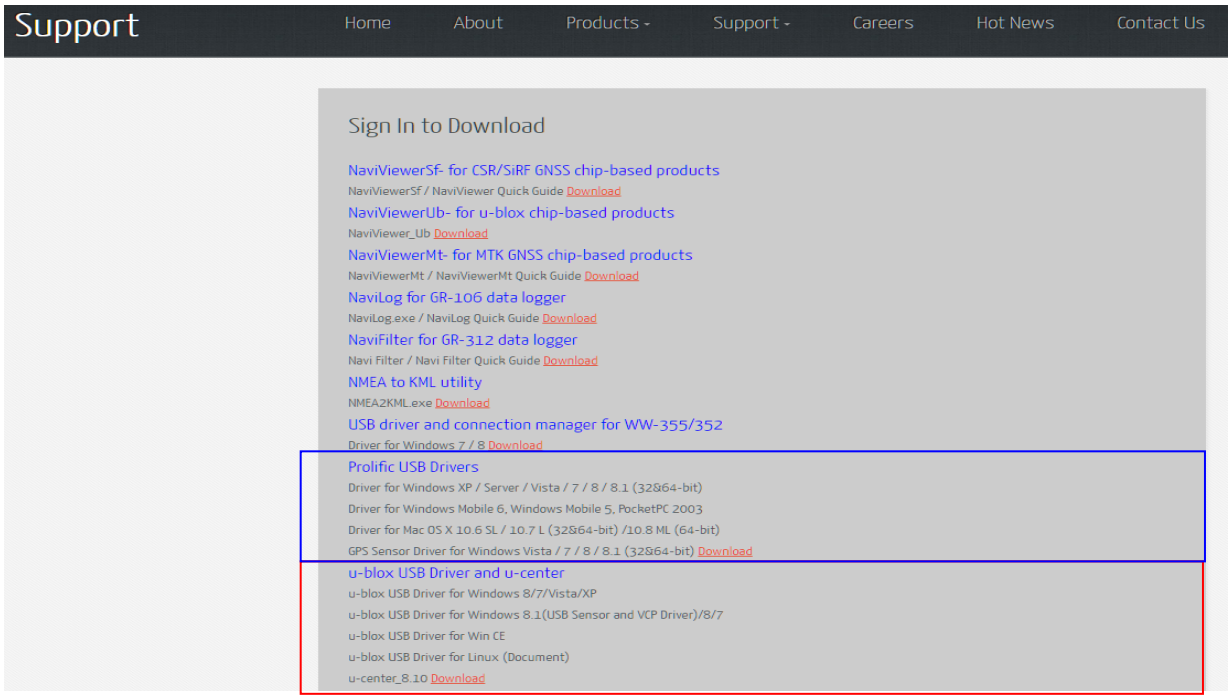


4.2 USB Drivers

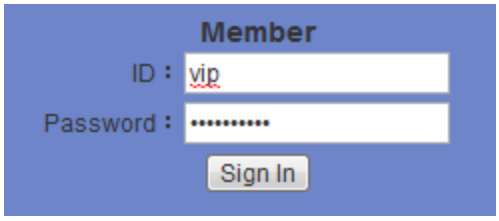
USB drivers are available from Navisys download link as shown below: http://www.navisys.com.tw/support.html

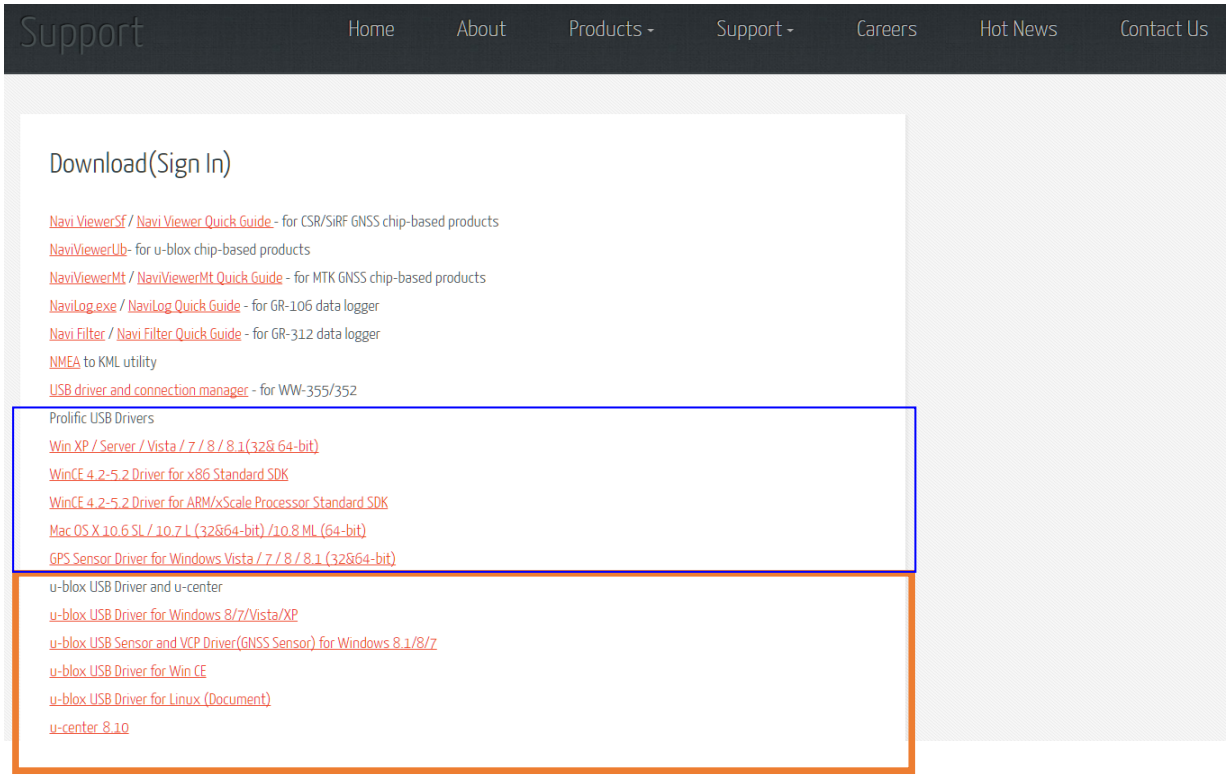
For USB interface, please select u-blox USB driver. For TTL, RS232 interfaces and GR-701W, please select the Prolific USB driver.

Linux and *BSD include the required USB drivers in the stock kernel.



- Click on Download and it prompts for ID and password. Enter ID and Password and then click on Sign In to download the drivers. The default password is “navi-utility”. Navisys may change the ID and password.





4.3 Ordering Information

GR-701X

T	TTL; mini-din 6-pin male connector
R	RS232; mini-din 6-pin male connector
U	u-blox USB; type A connector
W	Prolific USB, PPS connected to DCD; type A connector

4.4 Related Document

[1] u-blox 7 Receiver Description Including Protocol Specification V14
http://www.u-blox.com/images/downloads/Product_Docs/u-blox7-V14_ReceiverDescriptionProtocolSpec_Public_(GPS.G7-SW-12001).pdf

5 Electrical and Environmental Data

Electrical Data

Power Supply (VDC)	3.3 ~ 5.5
Power Consumption	37 mA / average tracking (9 SVs) 13.5uA / backup power (module disabled)
Backup power	3.3 V
USB I/O (V)	VIH: 2.0 ~ VDD_USB (VDD_USB: 3.3V) VIL: 0 ~ 0.8 VOH >= 2.8 VOL<= 0.3
Digital I/O (V)	VIH: 0.7*VDD_IO ~ VDD_IO (VDD_IO: 3.3V) VIL 0 ~ 0.2*VDD_IO VOH >= VDD_IO-0.4V VOL<= 0.4
Protocols	NMEA (default)

Environmental Data

Operating temperature	-40 ~ 85℃ (-20~60℃ for backup battery)
Storage temperature	-40 ~ 85℃ (-40~60℃ for backup battery)
Vibration	5Hz to 500Hz, 5g
Shock	Half sine 30g/11ms
RoHS compliant	Yes