Interpreting GNSS Specifications

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GNSS Specifications

- GNSS Related
  - GNSS Signal Capabilities
  - Antenna
  - Proprietary Technologies
  - Input / Output Data Formats
  - Positioning Performances
    - SPS, DGPS, RTK
  - Communication Interface
  - Data Logging / Storage
  - User Interface / GUI
- Application Specific
- Physical Properties
- Environmental Properties
- Electrical Properties
- Security
- Regulatory and Compliances

GNSS Specifications: Signal Capabilities

- GNSS Signal Capabilities
  - GNSS Satellites
    - GPS, GALILEO, GLONASS, BDS, QZSS, NAVIC, SBAS
  - GPS Signals in each satellite
    - GPS: L1 C/A, L2E (L2P), L2C, L5
    - GLONASS: L1 C/A2 and unencrypted P code, L2 C/A and unencrypted P code, L3CDMA
    - Galileo: L1 CBOC, E5A, E5B & E5AltBOC, E6
    - BeiDou: B1, B2, B3
    - QZSS: L1 C/A, L1C, L1 SAIF, L1S3 , L2C, L5, LEX/L64
    - IRNSS: L5, S-Band
    - SBAS: L1 C/A (EGNOS/MSAS), L1 C/A and L5 (WAAS)
    - L-Band: (Correction Services)

GNSS Specifications: Antenna Types

- Antenna : What type of Antenna?
    - Internal or External Antenna
    - Active or Passive Antenna
        - All external antenna are almost active antenna
        - Internal antenna may be passive or active
        - Active Antenna has LNA
            - LNA Gain: 20dB / 30dB / 45dB
    - Multi-Frequency Capability ?
        - GPS/QZSS/GALILEO : L1, L2, L5, L6
        - GLONASS : L1/L2/L3
        - BDS: B1/B2/B3
        - NAVIC: L5/S
    - Antenna for CORS or High-Accuracy Survey
        - Antenna with Choke Ring?
        - Calibrated Antenna?
            - PCO and PCV data available?
    - Power Supply to Antenna
        - From the Receiver or External Power Supply

- Power Supply to Antenna
    - From the receiver?
    - External Supply
- Supply Voltage
    - Variable Power Supply, OK?
        - 3V – 18V DC?
    - Fixed Voltage ?
        - 5VDC
- Max. Permissible Cable Loss
    - How many dBs?

GNSS Specifications: Proprietary Technologies

- Multipath Elimination
- Weak Signal Tracking
- A-GNSS Capability
- RAIM / A-RAIM Capabilities
- Anti-Jamming Capabilities
- Anti-Spoofing Capabilities
- Spectrum Data for Noise Monitoring

GNSS Specifications: Input / Output Data Formats

- Correction Formats
  - RTCM2.x, RTCM3.x
  - Proprietary Formats
- Observation Data Formats
  - RTCM2.x, RTCM3.x, BINEX
  - Proprietary Formats
- Position Data
  - NMEA-0183 v2.0 or higher
  - Proprietary Formats

- Output Rate
  - 1Hz, 10Hz, 50Hz, 100Hz?
- Timing
  - 1PPS Output
  - 10MHz Clock Output
- Clock
  - 10MHz Output
  - 10MHz Input
- Event Trigger Output
- Support to other Sensors
  - Metrology, Tilt Sesnors

GNSS Specifications: Position Performance

- Position Performance
  - SPS
    - Without any correction
  - DGPS
    - Code-phase correction
  - RTK
    - Code and Carrier Phase Correction
  - N-RTK
  - PPP
  - PPP-AR
  - PPP-RTK

Differential Positioning

Code differential GNSS positioning5

Horizontal. . . . . .0.25 m + 1 ppm RMS

Vertical. . . . . 0.50 m + 1 ppm RMS

SBAS differential positioning accuracy6

Horizontal. . . . . .0.50 m RMS

Vertical. . . . . 0.85 m RMS

Static GNSS Surveying5

High Accuracy Static

Horizontal. . . . . .3 mm + 0.1 ppm RMS

Vertical. . . . . .3.5 mm + 0.4 ppm RMS

Static & Fast Static

Horizontal. . . . . 3 mm + 0.5 ppm RMS

Vertical. . . . . 5 mm + 0.5 ppm RMS

Real Time Kinematic Surveying5

Single Baseline < 30km

Horizontal. . . . . 8 mm + 1 ppm RMS

Vertical. . . . . .15 mm + 1 ppm RMS

Networked RTK7

Horizontal. . . . . 8 mm + 0.5 ppm RMS

Vertical. . . . . 15 mm + 0.5 ppm RMS

Initialization time . . . . typically <10 seconds

Initialization reliability. . . . . .typically >99.9%

Performance Measurement of RTK Accuracy

- A fix error and a variable error with respect to base-length is given
  - Such as : x cm + y ppm
  - Example: 2cm + 1ppm
    - There is a fix error of 2cm plus 1ppm error due to base-length between the Base and Rover
    - 1ppm → 1 parts per million
    - → 1cm of error in 1 million centimeter distance between the Base and the Rover
    - → 1cm of error in 1000000 centimeter distance between the Base and the Rover
    - → 1cm of error in 10000 meter distance between the Base and the Rover
    - → 1cm of error in 10 kilometer distance between the Base and the Rover
    - → **1cm of error for every 10Km of distance between the Base and the Rover**
    - → 4cm of error for 40Km of distance between the Base and the Rover
    - **Thus the total error is : 2cm + 4cm due to 40Km of base length**
  - The longer the base-length, the larger the error
    - Do not assume that this error is linear
    - And it may not be valid for longer base-lines
    - Normally the recommended base-length for RTK for a Geodetic Receiver is 40Km

Communication

- Serial Ports:
  - Number and Connector Types : 9-pin or Lemo
- USB
  - Number and Types
- Ethernet
  - HTTP, HTTPS, TCP/IP, UDP, FTP,NTRIP Caster, NTRIP Server, NTRIP Client
  - Proxy server, Routing table, NTP Server, NTP Client support
  - Email Alerts and File Push
  - WiFi: Access point and client mode
  - Bluetooth

GNSS Specifications: Data Logging

- Internal Data Logging
  - Available?
  - Capacity?
  - Max Data Logging Rate
- File Size
  - Single File Size and Duration
  - Automated breakdown of Files
  - File Formats
  - Naming Conventions
- Event-based Data Logging

GNSS Specifications : Physical and Environmental

- Receiver Size, Weight, Material
  - Metallic Body or Non-Metallic
- Operating Temperature
  - -20 - +40 °C / -20 - +65 °C / -40 - +65 °C / -40 - +80 °C / -40 - +125 °C
- Humidity
  - 100% Condensing
- Shock
  - 1m Drop Test
- Vibration
  - Is it ok for machines like tractors, dump vehicles?
- IP Certification

User Interface

- Display Panel in the Receiver
- LEDs to show working status
- Multiple Language Support
- Web-User Interface
- Customizable GUI Display?

Antenna Related

- Power Supply to Antenna
  - From the receiver?
  - External Supply
- Supply Voltage
  - Variable Power Supply, OK?
    - 3V – 18V DC?
  - Fixed Voltage ?
    - 5VDC
- Max. Permissible Cable Loss
  - How many dBs?

Electrical Properties of Receiver

- Input Power Supply
  - Voltage Range
    - Shall be variable such as 5V – 18V DC
  - Car battery Supply
  - Internal Chargeable Battery
    - In some cases, not good for transport reason
    - Best for COORS
    - Removable Battery Packs?
      - Hot Swap Possible?
    - Power Charging Unit?
- Power Consumption
  - How many watts? (In typical condition)

Regulatory and Compliances

- Does it meet FCC Part 15
- Country based Radio Regulations
  - Including WiFi, BT or Radio Devices if any
- Li-Battery Related
- RoHS (Lead Free)

Applications, Requirements and GNSS Price

No	Application Type	Requirements	Working Environments	Receiver Type	Antenna Type	Price Range Dollars
1	Geodetic Survey	1cm or better	Post-Processing CORS	High-End CORS (Base-Station) High-End Survey Grade Receiver	Choke Ring GNSS Antenna	> $15,000
2	Precision Farming Mapping, Surveying, GIS	3 – 10 cm	Real-time output data to other systems Real-time data logging All weather operation Used in Tractors Remote data monitoring	High-End Base-Station Middle –End Dual Frequency Receiver RTK Capability	Multi-Frequency, RTK use	Few thousands
3	Mapping, Surveying, GIS	30 – 100 cm	Real-time output data to other systems Real-time data logging All weather operation	High-End Base-Station Low-Cost Dual Frequency Receiver RTK Capability	Multi-Frequency, RTK use	Few hundreds to few thousands
4	Car Navigation	3 – 10 m	Real-time output data to other systems Real-time data logging All weather operation	Standard Positioning Receiver Low-cost receivers	Standard GNSS antenna	< $100
5	ITS	30cm – 100 cm Lane Level Accuracy	Real-time output data to other systems Real-time data logging All weather operation	High-End Base-Station Low-Cost Dual Frequency Receiver RTK Capability		< $100 + Service Fee
6	LBS, Embedded devices	Standard Accuracy	Receiver embedded in mobile phones, tablets and other devices	Any type of standard GNSS chipset Preferably L1/L5	Standard antenna	Few Dollars

Prices are just for comparison purpose

backup

CDMA vs. FDMA

	CDMA [GPS, QZSS, Galileo, BeiDou, IRNSS, Future GLONASS Satellites]	FDMA [GLONASS]
PRN Code	Different PRN Code for each satellite Satellites are identified by PRN Code	One PRN Code for all satellites Satellites are identified by center frequency with frequency offset values for each satellite
Frequency	One Frequency for all satellites	Different frequency for each satellite
Merits & Demerits	Receiver design is simpler No Inter-Channel Bias More susceptible to Jamming	Receiver design is complex Inter-channel bias problem Less susceptible to Jamming

Note: New GLONASS satellites also broadcast CDMA signals

PPM

1 PPM Error

- 1 parts per million
- 1 meter of error every 1 million meter
- 1 cm of error every 1 million centimeter
- 1 cm of every 10,000 meter
- **1 cm of every 10 kilometer**

0.1 PPM Error

- 0.1 parts per million
- 0.1 meter of error every 1 million meter
- 0.1 cm of error every 1 million centimeter
- 0.1 cm of every 10,000 meter
- **0.1 cm of every 10 kilometer**
- 1 cm of every 100 kilometer

Time and Distance

1 PRN code is 1023 bits long and takes 1ms of time from start to end bit
c = 3e8 m/s;
t = 1e-3 s;
d = c * t = 300000m
Thus, 1 bit is about 300m long

Distance between Receiver and Satellite
c = 3e8 m/s;
t = 65ms
d = c * t = 20400000m = 20400Km

Time required to reach a signal from communication satellite to a receiver
c = 3e8 m/s;
D = 36000Km
t = d/c = 36000000/3e8 = 0.12s = 120ms