Hot Start on OEM7

Contents

Background

A key performance attribute of a GNSS receiver is the time from power on until it has a position, which is known as time to first fix (TTFF). The TTFF can be improved if the receiver has access to information such as an approximate position, approximate time, almanac, and ephemeris.

GNSS receivers track signals to measure the distance to satellites (pseudorange) and download the satellite positions plus time information from the navigation message. Tracking of at least 4 satellites is required to compute a position and time.

All information in this application note applies to the 7.08.00 firmware release, and applies to TTFF based on GPS L1 C/A.

GPS Navigation Data

In GPS, the navigation message is broadcast in several parts. The GPS SIS ICD defines this for GPS L1 C/A:

- Complete data message – 37500 bits at 50 bps (750 seconds or 12.5 minutes), made up of 25 frames
- Frame – 1500 bits (30 seconds), made up of 5 subframes
- Subframe – 300 bits (6 seconds), made up of 10 words
- Word – 30 bits (0.6 seconds), which each include parity bits

The GPS time includes two components:

- The week number, which started at week 0 on January 6, 1980
- The seconds in the week, which starts at 0 each week at midnight Saturday UTC.
    - The GPS time is not affected by leap seconds, so GPS is actually 18 seconds ahead of UTC as of December 2021. The current GPS leap second offset is broadcast in the almanac.

The seconds in the week is broadcast in every 6-second navigation message subframe, but the week number is only once per frame, in each subframe 1. A complete ephemeris is also once per frame, in subframes 1-3. A complete almanac is once per complete data message, in subframes 4-5. Thus, the almanac takes much longer to collect than the ephemeris.

Start Definitions

Cold Start – In a cold start, the receiver does not have an approximate position, approximate time, almanac, or ephemeris. As a result, it must search for all satellites at all Doppler values to acquire them. It then must decode the time from the navigation data, decode the week number (which is only in subframe 1), and then decode the ephemeris from subframes 1-3 to compute a position.

Warm Start – In a warm start, the receiver has an approximate position, approximate time, and almanac, but not an ephemeris. As a result, it can narrow its search to only the satellites in view at specific Doppler values. It also knows the week number, so time can be set from any one of subframes 1 through 5. It still must decode an ephemeris from subframes 1-3 to compute a position.

Because subframes 1-3 are still required, the only time savings from a warm start is from the initial acquisition of the satellites. NovAtel receivers use sophisticated acquisition algorithms, so typically that only takes a very short time after boot-up under good signal conditions. As a result, a warm start does not provide a major benefit to TTFF compared to cold start under good signal conditions.

Hot Start – In a hot start, the receiver has an approximate position, approximate time, almanac, and ephemeris. The benefit compared to warm start is that it only needs to collect one subframe to set time and compute a position, since it already has the ephemeris.
From the time of acquisition, in a cold or warm start it can take as long as 35.999 seconds to decode an ephemeris, but it only takes a maximum of 11.999 seconds to decode the time. On average, it would be about 29 seconds to get an ephemeris, but only 9 seconds to set time, so a significant reduction.

The NovAtel OEM7 product sheets have a cold start value of 39 seconds and a hot start value of 20 seconds. This also includes the time for the receiver to boot after power is applied.

Configuring a Hot Start

This section contains information on how to put the receiver into a hot start. The following commands are required:

- SETAPPROXPOS
- SETAPPROXTIME
- RAWALM or ALMANAC
- RAWEPHEM or GPSEPHEM

These commands can also assist for a receiver tracking other GNSS constellations, or if the UTC time is desired. These are optional:

- GLORAWALM or GLOALMANAC
- GLORAWEPHEM or GLOEPHEMERIS
- GALINAVRAWALMANAC or GALALMANAC
- GALINAVRAWEPHEMERIS or GALINAVEPHEMERIS
- BDSEPHEMERIS
- BDSALMANAC
- IONUTC

The navigation data commands are the same as the navigation logs collected by the receiver. To enable a hot start, the receiver also accepts them as commands. The raw logs are much shorter, so those are recommended over the decoded ones. There are no raw logs for BeiDou.

Note that the RAWALM, ALMALMANAC, GLORAWALM, GLOALMANAC, and IONUTC logs are for the entire constellation, while the other navigation data logs listed above are one per satellite.

To see the receiver progress towards a position, the following logs are helpful:

- TRACKSTAT
- RANGE
- BESTPOS
- TIME

The approximate position doesn't require good accuracy, it can be within several kilometers. Here is an example command:

```
SETAPPROXPOS 51.15 -114.03 1100
```

The approximate time also doesn't require good accuracy, it can be within several minutes. However, it does need to have the correct week. Here is an example command:

```
SETAPPROXTIME 2184 490000
```

There are two ways to get the ephemeris or almanac. NovAtel receivers store this information in non-volatile memory (NVM) by default, to assist with acquisition and TTFF. An almanac is valid for a long time, up to 6 months. However, an ephemeris expires in about 2 hours. If the receiver has been running within the last 2 hours, it likely has a valid ephemeris and almanac already, so only the approximate position and time are required.

If the receiver has not been used recently, or has been FRESET, then the almanac and ephemeris must be entered as commands. The best way to do this is to get the information from another receiver. Record each log as an ASCII log (so RAWALMA and RAWEPHEMA), and then enter it as a command.

Here are the steps to do this:

1. Connect to the receiver

2. Enter the commands. The following example shows SETAPPROXPOS, SETAPPROXTIME, RAWALMA, and RAWEPHEMA.

```
SETAPPROXPOS 51.15 -114.03 1100

SETAPPROXTIME 2184 507000

#RAWALMA,COM1,0,63.0,SATTIME,2184,506334.000,02000020,cc1b,16407;2185,6144
0.000,36,1,8b0220a4ce34415b120f1ca7fd6200a10d13ef69b624187717ec4f42ffa4,2,
8b0220a4d0b742a8210f0e8ffd4e00a10e08ebd990c3c29b201282ab0018,3,8b0220a494b
5431fcf0f12effd6e00a10d7f19985628c179e825e4fdffb2,4,8b0220a49734440c890f0b
aafd4f00a10ce745a7048069956315f8e50015,5,8b0220a499b74531170f0a77fd6100a10
c9417ff05296b8e82faf9f7001c,6,8b0220a49c344613c50f1c43fd6100a10ca0ef1398d5
9e61281592100065,7,8b0220a49eb6477d950f05d3fd5900a10d566f34cfa23d9bfdb81f2
4003d,8,8b0220a4a1344837950f0ef0fd3500a10d0dc37b1a02406376fb15fa0004,9,8b0
220a4a3b64913510f070ffd4800a10cd843859b4a8d1d83d7d3d00015,10,8b0220a4a6354
a3b180f12d5fd7100a10d11197af19724e0c7c9f3dfffc5,11,8b0220a4a8b64b032c0f0c6
7fd50ffa10d86f146cd6865207ced0602ffed,12,8b0220a4ab374c44900f1300fd6100a10
ce09c7f0a322c88e19712efffc2,13,8b0220a4adb64d2ece0f1096fd5500a10cf049b2472
7da9c5c32341c0056,14,8b0220a4b0374e09d30f0836fd5600a10ccc9b46a77e6d23e088e
9faffd2,15,8b0220a4b2b54f71d00ff746fd3400a10d103f4a982b09504d4fbdf2002b,16
,8b0220a4b5375065370f12fcfd6100a10c2b9d41c51be392954031c7ffdd,17,8b0220a4b
7b55170db0f18bafd4400a10d44c6c47fc1770b73a4ea46004c,18,8b0220a4ba345211070
f1212fd5500a10cc5efc86a7cabea21094b26ffc9,19,8b0220a4bcb55349410f17e0fd410
0a10cf2c899d050863ed441790a0039,20,8b0220a4bf34542ce40ffee0fd5400a10d22136
a927bbef9464c9543001d,21,8b0220a4c1b455c6a90f0acafd4d00a10c8febce47d4f9f47
8483213001c,22,8b0220a4c43756374a0ffcb5fd5000a10d021549b4dc645e44f979c3007
b,23,8b0220a4c6b5570f770f0f9cfd6c00a10d24187c5771ff2302342304ffe1,24,8b022
0a4c9355862860ffb00fd4800a10d276be56c1fd70a256db123002b,25,8b0220a4d031595
2620f0ad2fd5900a10da99969a427498bd9dad6200042,26,8b0220a4d2b35a35050ffe5ef
d4d00a10ce197902e0cc2d6bf6991140036,27,8b0220a496b15b4f7c0f1494fd3c00a10cc
8c43e8719947e726170e2fffe,0,00000000000000000000000000000000000000000000000
00000000000000,29,8b0220a49e305d0efe0f1a02fd4300a10c0ac74a5c610f3c7442a6c5
fffc,30,8b0220a4a0b15e2bd50ffc2dfd4900a10c796fcb92901c8dfbfd4abfffed,31,8b
0220a4a3305f551a0f089efd5b00a10cc16fede90db77aeb7d7cecffe4,32,8b0220a4a5b1
602aa70f0999fd4b00a10d6d43f67c9ead15903611fcfff9,51,8b0220a4cbb7730f890000
00000000000fc0000000000000000000998d,55,8b0220a4b73377315a4b503430523654
45502038525a2b374f5833354f00,56,8b0220a4b9b0780cfeff0230f9fd0bfffffe000000
```

000f8912890712e0da,63,8b0220a4cb317fb9bcababbbca9ca9ac9999cbbbb0ababc0000f
c0000013*a6bac1ef

#RAWEPHEMA,COM1,11,65.0,SATTIME,2184,505200.000,02000020,58ba,16407;21,218
4,511200,8b0220a474a722100079300497359e8b666ac9e0ea3d7cce00000a13db45,8b02
20a475293df2072f31dee9b31df3970c6837c1122ba10cf4c17cce7d,8b0220a475afff32f
0c372ecfff1271359e51b22d4f18497ffa5463d03c7*d72dc1c5
#RAWEPHEMA,COM1,10,65.0,SATTIME,2184,506310.000,02000020,58ba,16407;31,218
4,511200,8b0220a4d12722100079300497359e8b666ac9e0e43d7cce00ffefec35af,8b02
20a4d1aa3d020031535221439802150510e6c17eca10d392a7cce7e,8b0220a4d22eff877
4e2a9b8003d26f12bde13f20db06d6affaa2b3de7b2*b9f70445
#RAWEPHEMA,COM1,9,65.0,SATTIME,2184,506310.000,02000020,58ba,16407;4,2184,
511200,8b0220a4d12722100179300497359e8b666ac9e0f79d7cce000008e598c7,8b0220
a4d1aa9dfead35e6c997bcd6fe7900c86cc40a56a10d56387cce7f,8b0220a4d22e000f4a9
c142d00022720d6c723698086cf16ffa6ae9dfcf9*af597352
#RAWEPHEMA,COM1,8,65.0,SATTIME,2184,506280.000,02000020,58ba,16407;25,2184
,511200,8b0220a4cea722100079300497359e8b666ac9e00c507cce0000341fe022,8b022
0a4cf295011e3316b408675ba0f4c052407a60ed5a10e113c7cce7d,8b0220a4cfafff799e
5e703fffea271377ca1e39274a21aeffa69a50093e*c69ee443
#RAWEPHEMA,COM1,7,65.0,SATTIME,2184,506310.000,02000020,58ba,16407;22,2184
,511200,8b0220a4d12722100079300497359e8b666ac9e0da367cce000050c398c8,8b022
0a4d1aa3600783481aba0fa9e00af0373ee281430a10d715f7cce7e,8b0220a4d22effd61a
3eb05c00392630f3d516badc5dc131ffa81d3619c6*bd6dff63
#RAWEPHEMA,COM1,6,65.0,SATTIME,2184,506310.000,02000020,58ba,16407;26,2184
,511200,8b0220a4d12722100079300497359e8b666ac9e00f507cce000021149412,8b022
0a4d1aa5010e935c5261646540f31034e1daa0ea0a10d50f97cce7f,8b0220a4d22e000d9c
854ec8001f264c4d1e1cba0cb4dfa4ffa4a0500325*5793d25e
#RAWEPHEMA,COM1,5,65.0,SATTIME,2184,506310.000,02000020,58ba,16407;1,2184,
511200,8b0220a4d12722100079300497359e8b666ac9e00b377cce00ffa4425ac3,8b0220
a4d1aa37f148268d7e8ce908f34f05b095d412dea10d6f467cce7f,8b0220a4d22efffdf45
e44a9ffd528312c0f1b3f241a072effaf4237fbfb*bd40dc8e
#RAWEPHEMA,COM1,4,65.0,SATTIME,2184,506310.000,02000020,58ba,16407;9,2184,
511200,8b0220a4d12722110071300497359e8b666ac9e003737cce000003d09b77,8b0220
a4d1aa73ff343831ea6f5e6efee401345d610a64a10d4ab87cce7d,8b0220a4d22efffe487
ad26efffe26d71b9d23684a938455ffa53273fe66*6d72f789
#RAWEPHEMA,COM1,3,65.0,SATTIME,2184,506310.000,02000020,58ba,16407;16,2184
,511200,8b0220a4d12722100079300497359e8b666ac9e0ea447cce00ffc7c8092c,8b022
0a4d1aa440e4c2fd4fbd5c2e00ce0065143ea0c20a10c7f6b7cce7c,8b0220a4d22e000aa2
3673ec00432795f69921e71be08698ffa5e9440756*bc592cb9
#RAWEPHEMA,COM1,2,65.0,SATTIME,2184,506310.000,02000020,58ba,16407;6,2184,
511200,8b0220a4d12722100079300497359e8b666ac9e009717cce0000520ffcd4,8b0220
a4d1aa71f203285d8eb2d01ff3cf013adc561320a10cf4847cce7f,8b0220a4d22e0023f40
82b900005282ae78c1b4bd59b8f9cffad4271f97b*86dde367
#RAWEPHEMA,COM1,1,65.0,SATTIME,2184,506310.000,02000020,58ba,16407;3,2184,
514800,8b0220a4d12722120069300497359e8b666ac9e004607daf00ffa9fda873,8b0220
a4d1aa6000a32cb9642a1b4c008d01fcf8991392a10dd9fb7daffd,8b0220a4d22e002c1e8
c69dfffbd27948afd197728cb49bfffac58601ade*d2043dec
#RAWEPHEMA,COM1,0,65.0,SATTIME,2184,505890.000,02000020,58ba,16407;32,2184
,511200,8b0220a4ae272210007930049735 9e8b666ac9e001207cce00ffd5fcd68b,8b022
0a4aeaa20ff1937cdf6da21e5ff5702aa79820a63a10dd9df7cce7f,8b0220a4af2f000248
eb9e97002626ffc00823779eb0fadaffa55a20fd9b*07a1e61f

3. The receiver will respond with <OK for the SETAPPROXTIME and SETAPPROXPOS commands. It will output a response like the example below for the navigation message logs (note the last character in the log name is an R, and the first field after the header is OK).

```
#RAWALMR,COM1,0,0.0,SATTIME,2184,506334.000,02000020,0000,16407;
OK*3a5ab793
#RAWEPHEMR,COM1,11,55.0,SATTIME,2184,505200.000,02000020,2079,16407;
OK*b7ef744a
```

4. Enter the following log commands to check progress.

```
LOG BESTPOS ONTIME 1
LOG TRACKSTAT ONTIME 5
LOG RANGE ONTIME 5
LOG TIME ONTIME 5
```

5. About 20 seconds after power on +/-3 seconds, it will have a position if the RF signal conditions are good. At this point, the BESTPOS log will report the solution status as SOL_COMPUTED.

```
#BESTPOSA,COM1,0,65.5,FINESTEERING,2184,510426.000,02000008,cdba,16407;
SOL_COMPUTED,SINGLE,51.15038984364,-114.03070513243,1097.7365,-17.0000,
WGS84,0.8603,0.8800,1.7211,"",0.000,0.000,35,32,32,32,00,06,39,33*ab4f078
```

Leap Seconds

As noted earlier, GPS time is offset from UTC due to leap seconds introduced since January 6, 1980. The GPS leap second offset is not required for the receiver to compute a position. However, it is required by the receiver to output an accurate UTC time in the TIME log.

Without an almanac, the receiver does not know the current leap seconds, so it uses a pre-configured value. In the TIME log, the UTC status is reported as WARNING. Here is an example:

```
#TIMEA,COM1,0,64.0,FINESTEERING,2184,504170.000,02040020,9924,16407;VALID,
-1.028604619e-09,1.095198340e-09,-18.00000000000,2021,11,19,20,2,32000,
WARNING*640628db
```

There are two ways for the receiver to know the leap seconds. If the receiver is tracking GLONASS, then it can determine this from the GPS-GLONASS time offset. In this case no user commands are required.

If it is not tracking GLONASS, the receiver needs the leap second information from the ALMANAC, and it is reported in the IONUTC log. This information is only broadcast once per complete data message, so it may take up to 750 seconds to receive. Sending the IONUTC log as a command means the UTC status will quickly be VALID.

Here is an example IONUTCA log/command:

```
#IONUTCA,COM1,0,65.5,COARSESTEERING,2184,501727.729,02000020,ec21,16407;1.
117587089538574e-08,-1.490116119384766e-08,-5.960464477539063e-08,
1.192092895507813e-07,9.830400000000000e+04,-1.146880000000000e+05,
-1.966080000000000e+05,7.208960000000000e+05,2185,61440,
0.0000000000000000,-1.776356839e-15,1929,7,18,18,0*76682713
```

Here is an example of the TIME log with and without the IONUTC information.

```
#TIMEA,COM1,0,57.0,FINESTEERING,2184,510870.000,02040020,9924,16407;VALID,
-1.005595977e-08,1.008221171e-09,-18.00000000000,2021,11,19,21,54,12000,
WARNING*3b4bec81
#IONUTCR,COM1,0,0.0,FINESTEERING,2184,506334.172,02000020,0000,16407;OK*f1
990790
#TIMEA,COM1,0,63.5,FINESTEERING,2184,510875.000,02040020,9924,16407;VALID,
-7.790558182e-09,9.766775439e-10,-18.00000000028,2021,11,19,21,54,17000,
VALID*cd513304
```

Troubleshooting Slow TTFF

There are a few reasons why the TTFF may be slower than expected:

- Obstructions – confirm the antenna is outside, and there are no buildings blocking the sky.
- RF interference – check the ITDETECTSTATUS log. If there are other electronics or cabling close by, then move them further away from the antenna and cabling if possible, and use copper tape to shield the other electronics and cabling. A user can enable features from the interference toolkit to mitigate the interference.
- Antenna – does the antenna gain meet the electrical specifications? Those are given on pages like this.
- Antenna cabling – double check that the cabling is tight, and possibly test another cable. NovAtel cable recommendations are on this page.
- Incorrect approximate time – confirm the time, since if it is incorrect the receiver will search for satellites in the wrong locations.
- Incorrect approximate position – confirm the position, since if it is incorrect the receiver will search for satellites in the wrong locations.
- An expired ephemeris means it will be a warm start, so around 20 seconds slower than hot start.

NovAtel Support

To help answer questions and/or diagnose any technical issues that may occur, the NovAtel Support website is a first resource. Remaining questions or issues, including requests for temporary authorization codes, can be directed to NovAtel Support. To enable the online form and submit a ticket, first select a "Product Line" and then an associated "Product" from the list.

Documentation

Complete details on receiver installation, operation, and the logs and commands described in this application note can be found in the OEM7 Receiver Documentation Portal.

Contact Hexagon | NovAtel

support.novatel@hexagon.com 1-800-NOVATEL (U.S. and Canada) or 1-403-295-4900
For more contact information, please visit novatel.com/contact-us