



HEXAGON



APN-104

Position Seeding Guide and Recommendations





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Introduction: Position Seeding

Position seeding involves injecting position or alignment information into an alignment or convergence method to achieve that alignment or convergence faster upon boot-up. PPP (precise point position) seeding is a convergence method whereby position information from a previous powerup or from an already known position can be injected into the system to accelerate PPP convergence. INS (inertial navigation system) seeding is an alignment method whereby INS alignment information from a previous powerup can be injected into the system at startup to achieve INS alignment faster.

Through this application note, a user will be able to configure PPP or INS seeding on their OEM7 receiver (capable of PPP or INS) using recommended configuration and suggestions.

PPP Seed

Introduction

PPP¹ is a positioning method that uses precise, globally-applicable GNSS corrections to obtain a solution with centimetre-level accuracy. A typical PPP position solution requires a period of time to resolve any local biases and converge to centimetre accuracy. These convergence times may extend to several minutes and are dependent on observing conditions including the number of visible GNSS signals, level of multipath, and proximity to obstructions like trees or buildings.

To decrease the convergence time and therefore, the wait time until a user can begin their application with the desired accuracy, position seeding can accelerate convergence: position information from a previous powerup or from an already known position can be injected into the system to accelerate PPP convergence.

Seeding on a Stationary vs Dynamic Platform

Injecting the position information can be done while the platform is static or dynamic. The seed position must be in a datum consistent with the PPP corrections that will be used. For TerraStar corrections, this is ITRF2014. The PPP seed may be rejected if the seed position is significantly different due to datum differences.

Stationary and Dynamic Platforms

For PPP seeding on a stationary platform, the dynamics of the PPP filter must be configured before setting the PPP seed. By setting `PPPDYNAMICS AUTO`, the receiver detects the antenna dynamics and adapts filter operation accordingly. `PPPDYNAMICS STATIC` can also be used, depending on if the vehicle or platform is static or dynamic.

`PPPDYNAMICS AUTO`

`PPPSEED SET [latitude] [longitude] [height] [northing_std_dev] [easting_std_dev] [height_std_dev]`

For setting the seed while in dynamic mode, `PPPDYNAMICS DYNAMIC` or `PPPDYNAMICS AUTO` can be used:

`PPPDYNAMICS AUTO`

`PPPDYNAMICSEED [week] [seconds] [latitude] [longitude] [height] [northing_std_dev] [easting_std_dev] [height_std_dev] [northing_easting_covariance] [northing_height_covariance] [easting_height_covariance]`

Note: the covariance parameters in the `PPPDYNAMICSEED` command are optional.

¹ [APN-061: TerraStar® Correction Services](#)

Seeding with Previous Position Automatically

Injecting the position information can also be done with using the stopping position of the previous power-down. For example, in agricultural operations a tractor might be stopped in a field at the end of a day and then re-started the next day at the same position. Before the receiver is powered-down, the current PPP position could be saved to NVM to use at the next powerup. This can be configured using the following:

```
PPPSEED STORE  
PPPSEED RESTORE
```

The STORE and RESTORE options are intended to simplify seeding in operations where the antenna does not move between power-ups. The PPPSEED STORE command stores the PPP position and then that position is applied as a seed after power-up using PPPSEED RESTORE.

PPPSEED AUTO automates the STORE and RESTORE process. When this option is used, the PPP filter automatically starts using the position the position saved prior to powering down in the last session. While the position seed is saved every 2 seconds to NVM, only the last saved position seed will be injected upon start-up.

For this PPPSEED AUTO command to work, the PPPDYNAMICS command setting must be AUTO so that the receiver can determine when it is static, or the filter must explicitly be told it is static using PPPDYNAMICS STATIC. AUTO seeding will automatically detect when the vehicle is static and will only store seeds to NVM when static. Additionally, for the receiver to recall the saved seed, the PPPSEED AUTO command should be saved to NVM using the SAVECONFIG command. This can be configured using the following:

```
PPPDYNAMICS AUTO  
PPPSEED AUTO  
SAVECONFIG
```

Automatic seeding with this configuration is ideal for use cases where the vehicle does not move while the receiver is powered down and when the receiver does not move relative to the vehicle.

For special-case applications, such as a receiver mounted on a combine harvester, where the receiver may move relative to the vehicle, manual PPP seeding is more appropriate.

Seeding in a Combine Harvester Use Case Application

On a combine harvester, the receiver is typically mounted on the grain tank lid or extension that can open and close on a hinge. When the grain tank is not in use, the combine will close the grain tank, thus moving the receiver relative to the vehicle.

In this case, using auto-seeding (i.e., PPPSEED AUTO) is not ideal because the receiver may store PPP seeds when the grain tank is closed (i.e., the grain tank extension has closed on its hinge), and the receiver is upside down. These stored positions will be of poor quality and will not be correct with respect to the operating position of the receiver. In this case, manual seeding (i.e., PPPSEED MANUAL) should be used so that the receiver only stores and restores seeds when it is in its operating position.

On an uninitialized platform (i.e., a PPP seed is not known or not stored in NVM), auto-seeding should be enabled. This will ensure that when the vehicle is static and PPP is converged, a seed will be stored to NVM.



To-reiterate, the suggested configuration for auto-seeding when the vehicle is static:

```
PPPDYNAMICS AUTO  
PPPSEED AUTO  
SAVECONFIG
```

Auto-seeding should be enabled while the combine is in use. Before closing the grain tank lid, the combine should be stopped and placed into park. This will allow auto-seeding to store a seed to NVM. At this point, seeding can be put into manual mode and this configuration can be saved. This will stop seeds from being automatically stored to NVM.

```
PPPSEED MANUAL  
SAVECONFIG
```

After those commands are issued, the grain tank can be closed, and the combine can be powered off. The last PPP seed stored to NVM will be that of the receiver in its operation position.

The next time the combine is powered on, PPP seeding will still be in manual mode. This will allow the operator to open the grain tank lid and return the receiver to its operation position before a PPP seed is applied. After the grain tank lid has been opened, auto-seeding can be enabled again:

```
PPPSEED AUTO  
SAVECONFIG
```

If there is a PPP seed stored in NVM, auto-seeding will automatically apply the seed. Once a PPP solution is computed, auto-seeding will, once again, begin automatically storing seeds to NVM when the vehicle is static.

RXCONFIG Log

The RXCONFIG log is used to output a list of all current command settings:

```
LOG RXCONFIG
```

In the RXCONFIG output line for PPPSEED, the following behaviour will occur after saving to configuration (i.e., sending the SAVECONFIG command):

- If “PPPSEED AUTO” is saved to configuration, it will display AUTO
- If “PPPSEED SET” or “PPPSEED STORE” or “PPPSEED RESTORE” are saved to configuration, it will display MANUAL
- If “PPPSEED CLEAR” is saved to configuration, it will display CLEAR

An example excerpt of “PPPSEED AUTO” being set from suggested configuration in 2.3 Seeding with previous position automatically:

```
#RXCONFIGA,ICOM1,1,91.5,FINESTEERING,2133,323804.375,02020020,f702,16407;#PPPDYNAMICSA,  
ICOM1,1,91.5,FINESTEERING,2133,323804.375,02020020,f702,16407;AUTO*4d5d159e*e78124d4
```

```
#RXCONFIGA,ICOM1,0,91.5,FINESTEERING,2133,323808.675,02020020,f702,16407;#PPPSEEDA,ICOM1,  
0,91.5,FINESTEERING,2133,323808.675,02020020,f702,16407;AUTO,0.000000000000,0.000000000000,  
0.000,0.050,0.050,0.050,0.000*b42364a9*aec4c33f
```

Note: when sending “PPPSEED SET” or “PPPSEED STORE” or “PPPSEED RESTORE”, there should be a 1 second delay added between configuring PPPSEED and sending the SAVECONFIG command. This allows sufficient time for the RXCONFIG command to re-write the PPPSEED line to display MANUAL and to have MANUAL displayed in the RXCONFIG on future power-ups. This is important for users to note during development when many commands are sent in succession.

Clearing a Seed Position

A PPP seed can be cleared using the following:

```
PPPSEED CLEAR
```

Monitoring PPP Seed Status

This [PPPSEEDSTORESTATUS](#) log reports the availability of the PPP seed stored in NVM. When the status is AVAILABLE, a seed has been stored in NVM and is available for recall:

```
LOG PPPSEEDSTORESTATUS ONCHANGED
```

The [PPPSEEDAPPLICATIONSTATUS](#) log is used to report the progress or outcome of the latest attempt to apply a static PPP seed. With the changes in 7.08 .00 firmware, mentioned in section 2.9 PPP Seeding differences between 7.06.01 and 7.08.00, vehicle motion during initial receiver position computation is allowed when the Status field shows PENDING_MOTION_ALLOWED. However, motion during position computation is best suited for customers that only need 10cm accuracy.

```
LOG PPPSEEDAPPLICATIONSTATUS ONCHANGED
```

PPPSEEDAPPLICATIONSTATUS provides the state of PPP seeding . The PPPSEEDSTORESTATUS provides the state of seeds stored in NVM. As a result, both logs should be used to monitor the PPP seeding process.

Recommended PPP Seed Configuration

For most applications that have the receiver mounted at a stationary location on the vehicle and where the vehicle will power-off and power-on at the same location, the following configuration is suggested:

```
LOG PPPSEEDAPPLICATIONSTATUS ONCHANGED  
LOG PPPSEEDSTORESTATUS ONCHANGED  
PPPDYNAMICS AUTO  
PPPSEED AUTO  
SAVECONFIG
```



PPP Seeding Differences Between 7.06.01 and 7.08.00

Before 7.08.00, while the PPP position was being computed, there was a minor wait time where the vehicle had to remain static. The PPPSEEDAPPLICATIONSTATUS log would initially show “UNAVAILABLE” and then it would then show “PENDING” while the position is computed. During the “PENDING” stage, the vehicle had to remain static and the user had to wait 3 minutes. Finally, when the position was computed and the seed was applied, it would display “APPLIED”.

From 7.08.00 and later, the PPP seeding algorithm has improved so that:

- Vehicle operations/motion can begin immediately; the user does not need to wait the full 3 minutes and can start moving when the PPPSEEDAPPLICATIONSTATUS log reports PENDING_MOTION_ALLOWED. It will still take the same amount of time for position to be computed and for the seed to be applied, but the filter can track motion and compute the position at cm level in 1.5 minutes. Due to starting vehicle motion earlier, there will be a slight decrease in accuracy. Motion during position computation is suitable for customers that only need 10cm accuracy.
- The new algorithm has improvements in detecting and rejecting bad seeds. Previously the algorithm could only detect bad seeds if they were over 7m from the estimated position. Now, the algorithm can detect a bad seed if it is ~30cm from the estimated position. Also, recovery from a bad seed is significantly faster.

INS Seed

Introduction

INS seeding is an alignment method whereby INS alignment information from a previous powerup can be injected into the system at startup to achieve an INS alignment faster. This is especially useful for systems that previously required kinematic alignment.

What is in an INS Seed?

An INS seed is comprised of three parts, the position, attitude, and IMU biases:

1. **Position:** This includes the current ECEF position (x, y, z) and undulation. It does not include the standard deviations for the position values.
2. **Attitude:** This includes the current roll, pitch, and azimuth.
3. **IMU biases (error model information):** This includes the current gyroscope and accelerometer biases of all three axis (X, Y and Z), therefore six biases in total.

When INS seeding is enabled, alignment data is automatically saved when appropriate, with no specific action required from the user. During subsequent power ups, the saved solution is compared to the current position of the system, and if valid, the alignment data is used to immediately initialize the inertial filter, making it navigation-ready.

Error model information is also saved with the seed data. In cases where the alignment information is rejected, the error model will still be used to aid filter convergence, although another method of alignment will be required.

In the following applications, INS Seeding is not necessary:

- An IMU with grade 2 or grade 3 as the IMU is capable of alignment through static/stationary alignment.
- When using a dual antenna enclosure or receiver card as a heading can be computed through the dual antenna. The heading would aid the INS alignment.

Enabling an INS Seed

This feature is enabled via the [INSSEED command](#). This command setting must be saved to NVM via the [SAVECONFIG command](#) to be used upon next system boot-up.

```
INSSEED ENABLE
SAVECONFIG
```

Saving an INS Seed for Use at Next Power-Up

Saving an INS Seed

After ensuring the INSSEED is enabled and saved to NVM, the receiver can begin the INS seed generation process. Before an initial INSSEED can be saved, a kinematic alignment routine must be performed. Two conditions need to be met for a seed to be generated and be considered valid:

1. The INS solution status must be converged, as indicated by the INS solution convergence flag in the inertial Extended Solution Status (see [Table: Extended Solution Status](#)). This step is complete when the INS Status field changes to INS_SOLUTION_GOOD.
2. The system velocity should be less than 0.2 m/s.

When these conditions are met, the required information is automatically saved to NVM. After the system completes convergence and is operating as normal, the system should come to a complete stop before powering off or resetting. A complete stop is required so that an INS seed can be saved.

If before powering down these conditions cease to be met, the saved alignment data is automatically discarded. Despite the alignment information is no longer being valid, the error model information is automatically retained as valid.

When the seed has been successfully saved for the first time, the [INSSEEDSTATUS](#) log can be used to check seed injection status and seed validity.

```
LOG INSSEEDSTATUSA ONNEW
```

When the seed has been successfully saved, the INSSEEDSTATUS will show an Injection Status of "NOT_INITIALIZED" and Validity Status of "ALLVALID". For example:

```
<INSSEEDSTATUS ICOM1 0 77.0 FINESTEERING 2112 496376.001 02000020 0d1f 15990
< NOT_INITIALIZED ALLVALID 0.6624 -1.2290 15.3014 -1632852.9455 -3662160.8332 4944894.8443
-17.0000 0 0 0 0
```

Using an INS Seed on Power-Up

After powering on the receiver, the system will check to see if a valid seed is available in NVM.

The INSSEEDSTATUS will show an Injection Status and Validity Status of, respectively:

- **PENDING, ALLVALID:** If the entire seed is valid
- **PENDING, ERRORMODELVALID:** If only the error model is valid

Once it is confirmed that a valid seed is available, the system will wait for a valid GNSS position then immediately inject the seed information. It is important to remain stationary through this process.

The INSSEEDSTATUS will show an Injection Status and Validity Status of, respectively:

- **INJECTED, ALLVALID:** If the seed is valid and has been injected successfully.
- **ERRORMODELINJECTED, ERRORMODELINVALID:** If only the error model is valid, then the system will need a kinematic alignment as well.

The INS Status Field will show `INS_ALIGNMENT_COMPLETE`.

Once the seed has been injected, validation is performed. Injection occurs before validation to minimize the down-time upon start-up. As a result, the INSSEEDSTATUS will show “INJECTED, ALLVALID” even before the validation process occurs:

1. **IMU Type:** Validates that the current IMU type to the IMU type in the seed to ensure the same type is used. For customers using a SMART antenna, the IMU validation would always validate to true as the IMU type cannot be changed when using a Smart antenna.
2. **Position:** Validates that the system must not have moved significantly from the seed position
 - Less than 10 meters in 3D position.
3. **Azimuth:** Validates the difference between the current azimuth and the seed azimuth:
 - Less than 10 degrees in azimuth.

If the system fails validation with any of the checks, the seed will be invalidated and the INS will be reset.

If the seed validation is rejected, the INSSEEDSTATUS will show an Injection Status and Validity Status of, respectively:

- **FAILED, INVALID:** A kinematic alignment is needed.

The INS Status Field may report `INS_INACTIVE` for 1-2 epochs as the system is reset and the normal process for a kinematic alignment initiated.

Combine Use Case

Similar to the explanation of the combine use case for PPP seeding as described in 2.4 Seeding in a combine harvester use case application, the receiver is mounted on the grain tank extension. The grain tank extension can open and close on a hinge. When the grain tank extension is in the closed position (i.e., the extension flaps may be folded into the hopper), the receiver is pitched backwards or is inverted.

While inverted the receiver may get enough GNSS signals to compute a position and therefore allow the INS to align. When the extension is then opened (i.e., the extension flaps are folded out), the attitude solution and direction may be backwards to what is expected.

To prevent the system from aligning in the grain tank extension closed position, the [SETALIGNMENTORIENTATION command](#) can be used to enable or disable the orientation verification condition for INS alignment. If the observed roll or pitch of the unit differs from the expected roll and pitch by more than the threshold, INS alignment will not occur. Expected orientation is specified using the `SETINSROTATION RBV` command.

This command is specifically designed for use on smart antenna products where the GNSS antenna is rotating with the IMU and the customer wants to ensure the enclosure is in the proper orientation (right side up) prior to SPAN completing alignment.

To enable this feature, the suggested configuration is:

```
SETALIGNMENTORIENTATION ENABLE [Roll/Pitch Threshold]
```

The default angle threshold is 60 degrees, but can be adjusted to a threshold between 0 – 90 degrees.

Handling the INS Seed

It is also possible to clear the currently saved seed value from NVM so it will not be used until re-saved:

```
INSSEED CLEAR
```

Note: the FRESET command will clear the currently saved seed value and the INS seed configuration.

For advanced users, it is possible to force the seed to be used. However, it can result in an unstable INS solution if the vehicle has moved:

```
INSSEED ENABLE INJECT
```

Note: an INS seed cannot be created manually by users (and then be injected).

Recommended INS Seed Configuration

For most applications requiring INS seeing, the following configuration is suggested:

```
LOG INSSEEDSTATUSA ONNEW  
INSSEED ENABLE  
SAVECONFIG
```

Useful Logs

INSSEEDSTATUS

The INSSEEDSTATUS log reports the seed injection status for the current power up and information on current seed validity. When the Injection Status and Validity Status, respectively, are in “INJECTED, ALLVALID”, this means that the INS seed is valid and has been successfully injected into the alignment solution.

INSATTX

The INSATTX log includes the information from the INSATT log, as well as information about the attitude standard deviation. The position type and solution status fields indicate whether the corresponding data is valid.

Users can check the INS Status to monitor the alignment status, the Pos Type to monitor the position solution status, and the “Ext sol stat”. For the “Ext sol stat”, the field is populated with a hexadecimal value which can be decoded for specific information related to the INS seed. In the following example, the “Ext sol stat” field has a value of 97000055. The INS Status is in INS_SOLUTION_GOOD.

```
<INSATTX ICOM1 0 76.0 FINESTEERING 2112 504178.000 02100020 5d25 15990
```

```
< INS_SOLUTION_GOOD FIXEDPOS -1.165938495 0.772490487 15.190585071 0.4268 0.4260 0.0241  
97000055 0
```

Table 1: Ext sol status of 97000055

Ext Sol Status in hexadecimal	9				7				0				0				0				0				5				5							
Nibble	N7				N6				N5				N4				N3				N2				N1				N0							
Ext sol status in binary	1	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1
Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				

In the table above, the “Ext sol stat” of 97000055 is denoted by each nibble “N[#]”. The nibbles related to NVM seeding and alignment information are Nibbles 6 and 7 (N6 and N7).

N6	24	0x01000000	Turn on biases estimated	0 = Static turn-on biases not estimated (starting from zero) 1 = Static turn-on biases estimated
	25	0x02000000	Alignment direction verified	0 = Not verified 1 = Verified
	26	0x04000000	Alignment Indication 1	0 = Not set, 1 = Set Refer to Table: Alignment Indication
	27	0x08000000	Alignment Indication 2	0 = Not set, 1 = Set Refer to Table: Alignment Indication
N7	28	0x10000000	Alignment Indication 3	0 = Not set, 1 = Set Refer to Table: Alignment Indication
	29	0x20000000	NVM Seed Indication 1	0 = Not set, 1 = Set Refer to Table: NVM Seed Indication
	30	0x40000000	NVM Seed Indication 2	0 = Not set, 1 = Set Refer to Table: NVM Seed Indication
	31	0x80000000	NVM Seed Indication 3	0 = Not set, 1 = Set Refer to Table: NVM Seed Indication

Figure 1: Ext Sol Status - N6 and N7 decoding

Figure 1 shows the breakdown of bits 24-31 that comprise N6 and N7. Bits 26-28 are regarding alignment information. From the example:

- Bit 26: 1
- Bit 27: 0
- Bit 28: 1

From Table 2, having Bits 28-26 Values represent “101”, indicates that the “Completed Alignment Type” is “NVM Seed”. This means that INS seeding has been successfully used for alignment.

Table 2: Alignment Indication

Bits 28-26 Values	Hex Value	Completed Alignment Type
000	0x00	Incomplete Alignment
001	0x01	Static
010	0x02	Kinematic
011	0x03	Dual Antenna
100	0x04	User Command
101	0x05	NVM Seed

Figure 1 also shows the breakdown of bits 29-31, which “NVM Seed Indication” information. From the example:

- Bit 29: 0
- Bit 30: 0
- Bit 31: 1

From Table 3, having Bits 31-29 Values represent “001”, indicates that the “NVM Seed Type” is “NVM Seed Injected”. This means that INS seed has been injected and is valid.

Table 3: NVM Seed Indication

Bits 31-29 Values	Hex Value	NVM Seed Type
000	0x00	NVM Seed inactive
001	0x01	Seed stored in NVM is invalid
010	0x02	NVM Seed failed validation check
011	0x03	NVM Seed is pending validation (awaiting GNSS)
100	0x04	NVM Seed injected (includes error model data)
101	0x05	NVM Seed data ignored due to a user-commanded filter reset or configuration change
110	0x06	NVM Seed error model data injected

Recommended Use

INS Seed is most appropriate for applications where the system has an IMU that is grade 1 and the receiver is single antenna only. Also, the system must remain stationary/static after the power-up so that initialization and validation of the seed can be completed. This alignment method is best suited for agricultural applications where the systems will likely remain stationary, at the same location, between subsequent startups.

Recommended Troubleshooting Logs

For a problem with PPP or INS seeding, please refer to the appropriate section below, log the data suggested to a file on your computer for 15 minutes, and ensure that the data file collected demonstrates the issue. The data file and description of the issue can be sent to support.novatel@hexagon.com.

Recommended Troubleshooting Logs for PPP Seeding

LOG RXSTATUSB ONCHANGED
 LOG RAWEPHEMB ONNEW
 LOG GLORAWEPHEMB ONNEW
 LOG QZSSRAWEPHEMB ONNEW
 LOG BDSRAWNAVSUBFRAMEB ONNEW
 LOG GALFNAVRAWEPHEMERISB ONNEW
 LOG GALINAVRAWEPHEMERISB ONNEW
 LOG RANGE B ONTIME 1.0
 LOG BESTPOS B ONTIME 1.0
 LOG RXCONFIG B ONCE
 LOG VERSION B ONCE
 LOG TRACKSTAT B ONTIME 1.0
 LOG LBANDTRACKSTAT B ONTIME 1.0
 LOG PPPPOS B ONTIME 1.0
 LOG PPPSATS B ONTIME 1.0
 LOG TERRASTARINFO B ONCHANGED
 LOG TERRASTARSTATUS B ONCHANGED
 LOG PSRPOS B ONTIME 1.0
 LOG ALMANAC B ONNEW
 LOG IONUTCB ONNEW
 LOG GLORAWALMB ONNEW
 LOG GLOCLOCK B ONNEW
 LOG LBANDBEAMTABLE B ONCHANGED
 LOG PPPSEEDAPPLICATIONSTATUS ONCHANGED
 LOG PPPSEEDSTORESTATUS ONCHANGED

Recommended Troubleshooting Logs for INS Seeding

LOG RXSTATUS B ONCHANGED
 LOG RAWEPHEMB ONNEW
 LOG GLORAWEPHEMB ONNEW
 LOG BESTPOS B ONTIME 1
 LOG RANGE B ONTIME 1
 LOG RXCONFIG A ONCE
 LOG VERSION A ONCE
 LOG RAWIMUSXB ONNEW
 LOG INSUPDATESTATUS B ONCHANGED
 LOG INSPVAXB ONTIME 1
 LOG INSCONFIG A ONCHANGED
 LOG BESTGNSSPOS B ONTIME 1
 LOG INSSEEDSTATUS A ONNEW

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support.novatel@hexagon.com 1-800-NOVATEL (U.S. and Canada) or 1-403-295-4900
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