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BUREAU OF INDIAN STANDARDS
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मसौदा भारतीय मानक

NavIC रिसीवर - विशिष्ट

Draft Indian Standard
NavIC Receiver – Specification

ICS 35.020

Geospatial Information Sectional Committee, LITD 22	Last Date for Comments: **06 Nov 2024**

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FOREWORD

(Formal clauses of the draft will be added later)

Navigation with Indian Constellation (NavIC) is an independent navigation satellite system designed, developed, deployed and maintained by India. In a typical application leveraging NavIC services, there is a NavIC receiver, which receives the satellite signals through an internal/external antenna and computes the Position, Velocity & Time (PVT) of the user. There is an application software, which accepts the computed PVT solution as an input and provides value added services like displaying the PVT on a screen as latitude, longitude & altitude, displaying the position on a map, using the position for geo-fencing, using the time for synchronization of clocks, etc

Most of the NavIC receiver, product parameters remain the same across the different applications. However, there are some parameters like receiver sensitivity, dimensions, power source (battery life), output refresh rate, receiver dynamics, external assistance sources, jamming resistance, etc. which may vary from application to application. This standard is targeted at the performance of the NavIC receiver portion of the application only and not the application software, which provides the value-added services.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’.

Table of Contents

Indian Standard

NAVIC RECEIVER — SPECIFICATION

1 SCOPE

This draft Indian standard provides generic performance requirements and corresponding test cases for the NavIC receiver. These requirements would assist in ensuring the compatibility of NavIC receiver with NavIC constellation.

This standard is applicable to the generic applications like Mobile phones, vehicles etc. In addition to the requirements given in this standard, there may be additional requirements for certain specific applications like Defence, Space etc which are not covered in this standard.

2 REFERENCES

The references will be added later.

3 TERMS AND DEFINITIONS

Following terms and definitions, may be referred to as an adjunct towards this standard:

a) **Acquisition sensitivity:** When a NavIC receiver is turned on, one of the first operations the receiver carries out is to acquire the satellite signals. The sensitivity of the receiver for acquiring the satellite signals depends on the information available a-priori with the receiver. This information may be used to optimize the acquisition engine algorithm towards either improved sensitivity or towards improved speed of acquisition.

b) **Band-limited noise-like interference:** Band-limited noise-like interference refers to complex spectra. This type of interference affects the receiver in a noise-like manner and can disrupt the GNSS receiver's performance. For example, out-of-band emission is an emission on a frequency or frequencies immediately outside the necessary bandwidth, which results from the modulation process, but excludes spurious emissions. It raises the noise floor of the receivers and reduces the Carrier signal-to-Noise density ratio (C/N_0), impacting GNSS receiver performance.

c) **CEP/CEP_{50}:** CEP stands for Circular Error Probability and is a measure of 2-D accuracy for a given set of measurements. In case no qualifier is used post the letters CEP, it refers to CEP_{50}. It is defined as the radius of the circle that contains 50% of the error distributions when centered at the true (i.e. error free) location.

d) **Cold start:** A NavIC receiver is considered to undergo a “cold-start” when almanac, ephemeris, time and receiver coordinates are not known and pseudo-range & pseudo-range rate forecast is impossible. This happens when (a) a NavIC receiver is powered on after a long time, (b) its memory is flushed before turning it on; or (c) if it does not support any non-volatile memory storage. Under such conditions, the receiver has a wide search range in both the code and frequency domains and might be forced to use the coherent/non-coherent integration intervals optimized to minimize the dwell time in each individual frequency/code-phase bin.

e) **Continuous wave interference:** Continuous Wave (CW) interference is a type of interference that can affect the performance of Global Navigation Satellite System (GNSS) receivers. CW includes all signals that may be effectively represented as pure sinusoids. The extremely low power of GNSS signals makes them vulnerable to a wide variety of interfering signals, falling within the GNSS frequency bands. CW Interference is one of the main classes of these disturbing signals and can cause errors in the measurement of the time of arrival, thereby affecting positioning performance.

f) **C/N_0:** In the absence of interference, the Carrier to Noise-density ratio (C/N_0) is the ratio of the received GNSS signal carrier power C, in watts, to the noise power spectral density N_0. The noise power spectral density (N_0, in W/Hz) is given by following expression:

$$N_0 = kT$$

Where, k is Boltzmann's constant, 1.38×10^{-23}, in joules (equivalent to W/Hz) per Kelvin and T is the system noise temperature (in K). Using a decibel scale the baseline C/N_0 with no interference present is

$$C/N_0 = 10 \times log10(C/N_0)\ dBHz$$

When interference is present, a reduction in C/N_0 can occur that is equivalent to an addition of interference (I) W/Hz in the in-band noise floor and in some cases a reduction in signal power δc to the received satellite signal. The resulting Carrier to Noise-and-Interference-density ratio $C/(N_0+I)$, may be expressed as

$$C/(N_0 + I) = 10 \times log10((C - \delta c)\ /\ (N_0 + I))\ dBHz$$

Where, $\delta c = 0$, except for the case when the interference power is large enough to drive the UE (User Equipment) front end to a non-linear regime. The difference between these two conditions, that is the interference conditions versus the non-interference condition, is given by:

$$\Delta\, C/N_0 = C/(N_0 + I) - C/N$$

g) **Dwell time:** The dwell time in GNSS is the time required to test for the presence of a satellite signal for a certain combination of parameters (typically a combination of frequency Doppler range and code phase range commonly referred to as a search bin). The search process detects whether a GNSS satellite is present or not in an area of the sky, based on correlation of a received signal with a reference signal stored in the receiver.

h) **Hot start:** "Hot start" happens when almanac, ephemeris, time and coarse receiver coordinates are known and pseudo-range and pseudo-range forecast is possible. Hot-start occurs when satellite signal is momentarily lost owing to obstruction. Under such conditions the receiver has a narrow search range in both the code and frequency domains and hence can use the coherent/non-coherent integration intervals optimized to maximize the sensitivity in each individual frequency/code-phase bin.

i) **ICD:** Interface Control Document.

j) **Interference:** It is understood as any RF signal disturbing the terminal measurement. It can include intentional and unintentional interference. Intentional Interference includes jamming and spoofing while unintentional interference is typically caused due to leakage signals from RF signal sources in the vicinity. Interference characterization is possible based on the parameters such as frequency, power, Direction Of Arrival (DOA), delays (for multipath), and delay measurement.

k) **PRN:** PRN stands for Pseudo Random Noise code. It is a sequence of 1's and 0's that appears to be random electrical noise. It is an intelligently generated deterministic sequence of pulses (1's & 0's), that repeat after a defined period.

l) **Pulsed interference:** Pulsed interference is a common type of detrimental interference for Global Navigation Satellite System (GNSS) receivers. It can originate from radar systems and can severely degrade the performance of GNSS receivers. In a single-antenna GNSS receiver, the pulsed interference is usually handled by using pulse blanking or frequency excision techniques. In an antenna array system, more efficient mitigation of pulsed interference may be obtained by adding the spatial domain to the signal processing.

m) **Receiver input signal dynamic range:** A receiver operating in field will observe variable power levels of the satellite signals because of a myriad of factors like receiver antenna orientation (antenna gain roll-off), blockage due to foliage, roofing and other construction materials, multipath, etc… In this case, one satellite signal may be received by the receiver with a low power level and others may be received at nominal or high power level because of direct line of sight and receiver antenna pointing. In such scenarios, the receiver should be capable of acquiring and tracking all the satellite signals and not give false lock onto the cross-correlation peak of the high power and low power signals. This specification can be represented in terms of NavIC receiver dynamic range for signal acquisition and tracking.

n) **RMS error:** It stands for Root Mean Square error and is a measure of the precision of a given set of measurements. RMS (2D) refers to two dimensional errors and RMS (3D) refers to three dimensional errors. It is calculated using the following equations, where $\sigma_{x,y,z}$ refers to the standard deviation of the estimated coordinates along the corresponding axis.

$$RMS_{error}(2D) = \sqrt{\sigma_x^2 + \sigma_y^2}$$

$$RMS_{error}(3D) = \sqrt{\sigma_x^2 + \sigma_y^2 + \sigma_z^2}$$

o) **Receiver sensitivity:** The sensitivity of a receiver is an important performance parameter which determines whether a receiver can function in a given environment where the satellite signals may be attenuated due to different factors like low elevation angles (receiver antenna gain roll-off), foliage, blockage, etc.

p) **SEP:** SEP stands for Spherical Error Probable and is a measure of 3-D accuracy for a given set of measurements. In case no qualifier is used post the letters SEP, it refers to SEP_{50}. It is defined as the radius of the sphere that contains 50% of the error distributions when centered at the true (i.e. error free) location.

q) **SPS:** Standard Positioning Service i.e. service with access for civilian users.

r) **Steady state navigation:** A GNSS receiver is said to be in steady state navigation when it has acquired and tracked the satellites in view and outputs a position solution.

s) **Time to first fix (TTFF):** Time To First Fix (TTFF) of a NavIC receiver is defined as the time from switch-on to the first valid position determination under fixed initial conditions.

t) **Tracking sensitivity:** The tracking sensitivity of a NavIC receiver is the minimum signal strength at which the receiver can keep maintaining the synchronization between the incoming and local signals. The tracking sensitivity of a receiver is typically much higher than the receiver's acquisition sensitivity as a coarse synchronization is already available from acquisition which enables longer integration of the correlation values.

4 REQUIREMENTS

The specifications for the various features and capabilities for NavIC receiver shall be as given in Table 1. The manufacturer shall ensure compatibility and interfacing with application specific navigation equipment systems in the country.

4.1 Receiver NavIC SPS signal support capability

For a receiver to be qualified as supporting the NavIC SPS constellation, it shall have the resources allotted to acquire, track and make measurements to compute position using all in view NavIC satellites. The device under test shall support any of the NavIC signal frequencies i.e. L1 band (centered on 1575.42 MHz), L5 band (centered on 1176.45 MHz) and S band (centered on 2492.028 MHz). During the course of time, some of the NavIC satellites may reach end of life and hence be replaced with new satellites. The receiver shall be able to support by default or through configuration, these new satellites' PRN codes, which are chosen from the set of PRN codes mentioned in the NavIC open signal ICDs [1] [2]. From these two requirements the two performance parameters emerging shall be complied namely, the number of channels for NavIC satellite signals and the number of PRN codes supported. **For parameters, refer Table 1 (i).**

4.2 Receiver sensitivity

The receiver sensitivity parameter may be further divided into two parameters based on the different receiver operations, i.e. acquisition sensitivity and tracking sensitivity.

4.2.1 *Acquisition sensitivity*
Based on the information available with the receiver, its acquisition operation may be divided into two modes, cold-start mode and hot-start mode.

4.2.1.*1 Cold-start acquisition sensitivity*

A NavIC receiver shall be considered to undergo a cold-start when almanac, ephemeris, time and coarse receiver coordinates are not known and pseudo-range & pseudo-range rate forecast is impossible. Under such conditions, the receiver passes through a wide search range in both the code and frequency domains and might be forced to use the coherent/non-coherent integration intervals optimized to minimize the dwell time in each individual frequency/code-phase bin. Typical cold-start scenario occurs when the receiver is powered on after a long time (existing data is invalid), its memory is flushed before turning on or if it does not support any non-volatile memory storage. **For parameters, refer Table 1 (ii).**

4.2.1.2 *Hot-start acquisition sensitivity*

A NavIC receiver shall be considered to undergo a hot-start when almanac, ephemeris, time and coarse receiver coordinates are known and pseudo-range & pseudo-range rate forecast is possible. Under such conditions the receiver has a narrow search range in both the code and frequency domains and hence can use the coherent/non-coherent integration intervals optimized to maximize the sensitivity in each individual frequency/code-phase bin. Typical hot-start scenario occurs when the satellite signal is momentarily lost (when going under flyovers/blockages/short tunnels, when signal obstructed due to buildings, etc.). The re-acquisition performance of the receiver can also be tested against the same specification as it is a sub-set of hot-start acquisition. **For parameters, refer Table 1 (iii).**

4.2.2 *Tracking sensitivity*

Upon acquisition, the receiver determines a coarse synchronization with the incoming satellite signal and the local signal generated by the receiver. The receiver then moves onto tracking activity where the incoming signal and the local signal are synchronized using a tracking loop. The tracking sensitivity of a NavIC receiver is the minimum signal strength at which the receiver can keep maintaining the synchronization between the incoming and local signals. The tracking sensitivity of a receiver is typically much higher than the receiver's acquisition sensitivity as a coarse synchronization is already available from acquisition which enables longer integration of the correlation values. Tracking sensitivity of a receiver is an important parameter that determines the ability of the receiver to function nominally in the defined environment which may have different kinds of obstructions, foliage, etc. **For parameters, refer Table 1 (iv).**

4.3 Receiver accuracy

The output of a NavIC receiver consists of a combination of Position information, Velocity information and Time (PVT). However, depending on application, the receiver might use only one of the solutions or a combination of them. The accuracy of a measurement is the degree of closeness of an estimate to its true value while the precision of a measurement is the degree of closeness of a set of observations to their mean value. The accuracies expected from the receiver may vary a lot based on the application. The specifications for accuracy mentioned in this document are the bare minimum required to recognize a receiver as capable of receiving and using NavIC signals. **For parameters, refer Table 1 (v).**

4.4 Receiver dynamics

A receiver operating in a dynamic environment has to deal with the effect of receiver movement on acquisition and tracking of the signals. Due to the relative velocity between the receiver and the satellite, the carrier frequency is offset by the Doppler frequency shift. This Doppler frequency shift is tracked through the tracking loops and any variations in the velocity and acceleration of the receiver may lead to the signal slipping out of the loop. Therefore, the tracking loop design of the receiver should be capable of handling receiver motion and hence needs to meet the velocity and acceleration specifications. Some applications like receivers used on satellite launch vehicles, jet aircrafts, missiles, etc. may have higher requirements but the specifications given in this document are the minimum required for a NavIC receiver.

NOTE — this specification may not be applicable for the class of receivers that are expected to function in stationary mode. Example: CORS receivers, Survey grade receivers, Timing receivers, etc.

For values parameters, Table 1 (vi) (a).

4.5 Receiver input signal power dynamic range

A receiver operating in field will observe variable power levels of the satellite signals because of a myriad of factors like receiver antenna orientation (antenna gain roll-off), blockage due to foliage, roofing and other construction materials, multipath, etc. In this case one satellite signal may be received by the receiver with a low power level and others may be received at nominal or high power level because of direct Line of Sight (LoS) and receiver antenna pointing. In such scenarios, the receiver shall be capable of acquiring and tracking all the satellite signals and not give false lock onto the cross-correlation peak of the high power and low power signals. This specification shall be represented in terms of NavIC receiver dynamic range for signal acquisition and tracking.
For parameters, refer Table 1 (vii).

4.6 Receiver TTFF

Based on the definition of initial conditions, the TTFF specification is divided into two.

4.6.1 *Cold-start TTFF*

As defined in section 4.2.1.1., a receiver undergoing a cold start is assumed to not have information of almanac, ephemeris, receiver co-ordinates and velocity or any other data that can be used to forecast pseudo-ranges or pseudo-range rates. A typical cold-start scenario occurs when the receiver is powered on after a long time (existing data is invalid), its memory is flushed before turning on or if it does not support any non-volatile memory storage. The receiver operating conditions required for testing TTFF typically depend on the application. As per the scope of the current document, for generic receiver performance testing it shall be assumed to be stationary, seeing all the NavIC satellites mentioned in the ICD [1] [2], with the signal power in the min-max limits mentioned in the ICD [1] [2] and the receiver operating in a standalone NavIC mode (no assisted GNSS support).
Under such conditions, the cold-start TTFF is defined as follows, for values refer Table 1 (viii).

$$TTFF_{cold} = T_{warm-up} + T_{acquisition} + T_{tracking} + T_{data\_collection} + T_{pvt\_calculation}$$

Where,

a) $T_{warm-up}$ is the receiver warm-up time, which includes software and hardware initializations and therefore is highly dependent on the receiver type and the technology on which it is based;

b) $T_{acquisition}$ is the time that the receiver spends in acquiring the NavIC signals; it is driven by the NavIC signal at hand and the receiver resources;

c) $T_{tracking}$ accounts for the time to achieve tracking stability, i.e. convergence of the tracking loops and bit/ frame synchronization;

d) $T_{data\_collection}$ is the time that takes to decode the navigation message, namely the parameters of the navigation message that are relevant for the TTFF, depending on the starting condition;

e) $T_{pvt\_calculation}$ is the time to compute the navigation solution, namely initialization and convergence of the algorithms.

4.6.2 *Hot-start TTFF*

As defined in section 4.2.1.2., a receiver undergoing hot-start is assumed to have access to the almanac, ephemeris and coarse receiver coordinates and the receiver is able to forecast pseudo-range and pseudo-range rate., A hot-start scenario typically occurs when the satellite signals are momentarily lost (when going under flyovers/blockages/short tunnels, when signal is obstructed due to buildings, etc.). Conforming to the scope of the current document, the receiver operating conditions shall be assumed to be stationary, all NavIC satellite signals with nominal signal powers (within min-max signal power as mentioned in ICD [1] [2]) are visible and the receiver operating in a standalone NavIC mode without assisted GNSS support.
Under such conditions, the hot-start TTFF is defined as follows,

$$TTFF_{hot} = T_{acquisition} + T_{\ tracking} + T_{pvt\_calculation}$$

Where the terms in the equation have definitions as mentioned in section 4.6.1. on cold-start TTFF. For parameters, refer Table 1 (ix).

4.7 Receiver robustness to interference

A NavIC receiver operating in field will be subjected to different RF environments including unintentional interference, jamming and signal power leakage. The receiver design shall include elements to build resistance in the receiver towards these interference signals. This specification is targeted at making sure that the NavIC receiver performance does not degrade beyond an acceptable range in the presence of such interference and is robust enough.
The types of interference the receiver is expected to be subjected to are broadly divided into three categories, continuous wave interference, band-limited noise-like interference and pulsed interference.

4.7.1 *CW interference located in-band and near-band*

In the presence of continuous wave interference, the signal C/N_0 experiences a reduction due to the contribution of the CW interference in raising the noise floor while performing correlation. The performance parameter in this case, in addition to the receiver being able to perform positioning is given as follows**. For values refer Table 1 (x).**

After steady-state navigation has been established, NavIC receivers shall meet the performance parameters with continuous wave interfering signals present with a power level at the antenna port equal to the interference thresholds specified in **Table 1 (x) (a)** and **Table 1 (x) (b)** and shown in Fig. 1, Fig. 2 and
Fig. 3 with desired signal levels of greater than –132 dBm at the antenna port.

During initial acquisition of the NavIC signals prior to steady-state navigation, NavIC receivers shall meet the performance parameters with interference thresholds 6 dB less than those specified in **Table 1 (x) (a)**, **Table 1 (x) (b) and Table 1 (x) (c)**.

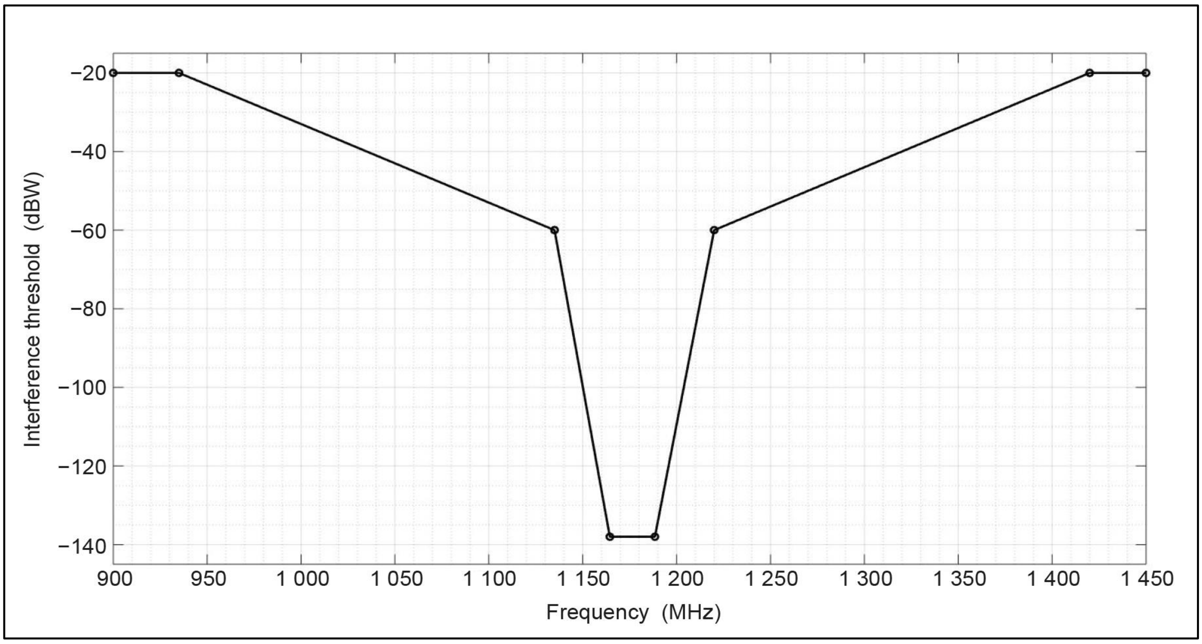

Fig. 1: CW interference thresholds for NavIC L5 band receivers in steady state navigation

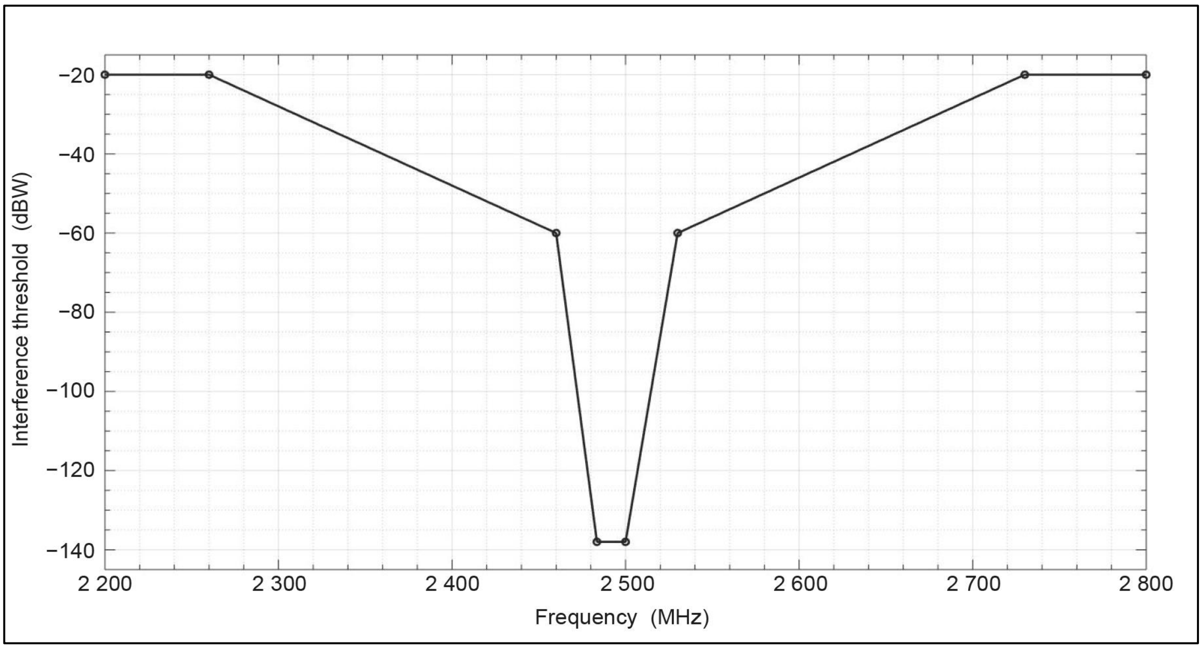

Fig. 2: CW interference thresholds for NavIC S band receivers in steady state navigation

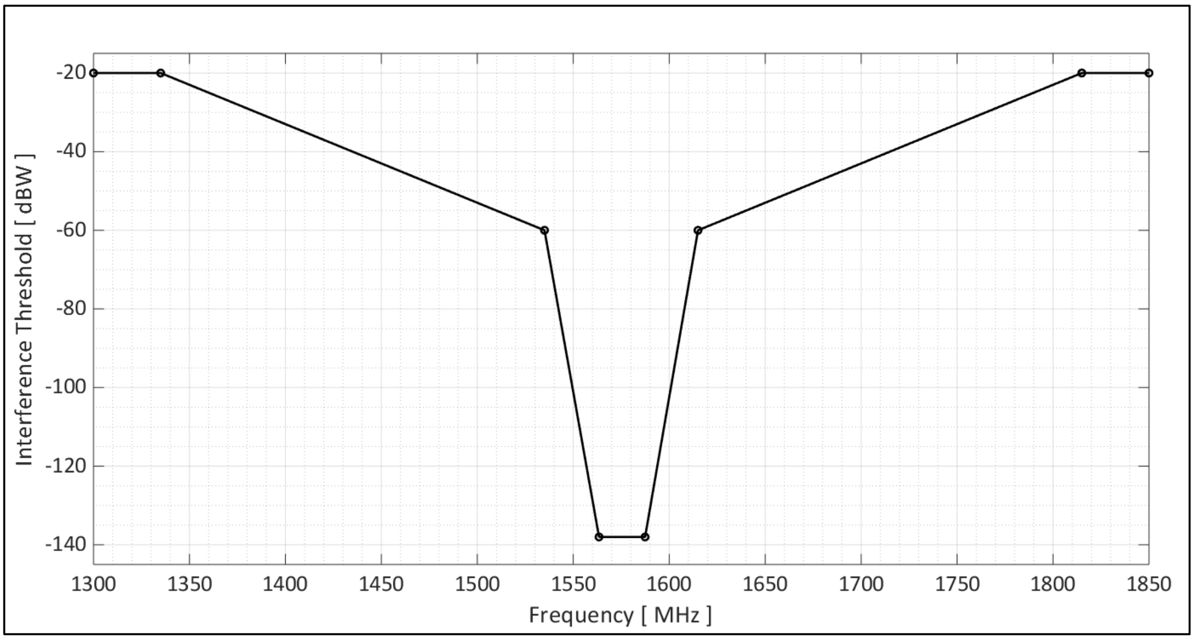

Fig. 3: CW interference thresholds for NavIC L1 band receivers in steady state navigation

4.7.2 *Band-limited noise-like interference*

In the presence of band-limited noise-like interference, the signal C/N_0 experiences a reduction due to the contribution of the band-limited noise-like interference in raising the noise floor while performing correlation. The performance parameter in this case in addition to the receiver being able to perform positioning is given as follows, **for parameters refer Table 1 (xi).**

After steady-state navigation has been established, NavIC receivers shall meet the performance objectives with noise like interfering signals present in the frequency range of L5 (1176.45 MHz ± 12 MHz), L1 (1575.42 MHz ± 12 MHz) and S (2492.028 MHz ± 8.25 MHz) with power levels at the antenna port equal to the interference thresholds specified in **Table 1 (xi) (a)** and Fig 4with the desired signal levels of greater than –132 dBm at the antenna port.

During initial acquisition of the NavIC signals prior to steady-state navigation, NavIC receivers shall meet the performance objectives with interference thresholds 6 dB less than those specified in **Table 1 (xi) (a).**

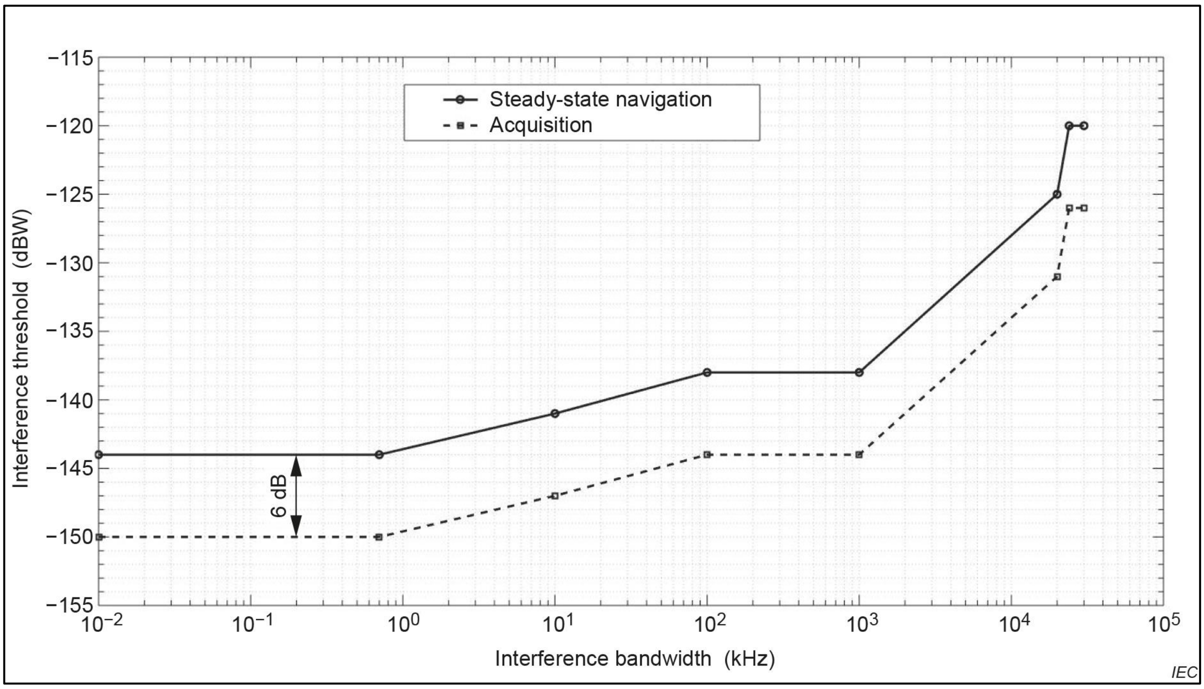

Fig. 4: Effect of interference bandwidth on interference thresholds for NavIC receivers (for noise like interference)

4.7.3 *Pulsed interference*

In the presence of pulsed interference, the received interference signal power is typically much greater than the receiver ADC thresholds and it usually leads to the ADC being saturated. In such a situation the input signal is not received and hence the acquisition cannot happen. However, since the interference signal is in the pulsed form, it typically lasts only a few micro seconds and hence tracking can still be carried out normally with appropriate mitigation techniques like pulse blanking. Hence, the receiver acquisition scenario is not considered and only the steady state scenario is considered. The performance parameter in this case in addition to the receiver being able to perform positioning is given in the specifications table. **For parameters, refer Table 1 (xii).**

After steady-state navigation has been established, the receiver shall meet the performance objectives while receiving pulsed interference signals with characteristics according to **Table 1 (xii) (a)** where the interference threshold is defined at the antenna port and the desired signal levels at the antenna port are greater than –132 dBm.

4.8 Receiver output formats

The output of a NavIC receiver is typically transmitted to a GUI for display or is transmitted to an application software or a system/sub-system which utilizes it. The interfaces through which the information is exchanged is dependent on the end use of the receiver, i.e., positioning or timing. For a generic NavIC receiver, it is expected to support the NMEA format of data exchange at the minimum to ensure access to debugging. **For parameters, refer Table 1 (xiii).**

4.9 Electromagnetic Compatibility (EMC) Requirements

The EMC requirements of the NavIC receiver shall conform to IS/CISPR 32.

5 MARKING

5.1 Each NavIC receiver shall be marked legibly and indelibly with at least the following information:

a) Manufacturer's name or trade mark (if any);
b) Model designation and Serial Number;
c) Country of manufacture;
d) Input supply voltage and frequency (If an external power adapter is provided, DC input voltage, polarity and wattage shall be marked on the TV and AC input voltage, frequency and wattage shall be marked on the power adapter);
e) Power consumption;
f) Input Terminals as applicable;
g) All Connectors and; and
h) Date of manufacture

5.2 The User Interface (UI) of the NavIC receiver shall display all the hardware input ports available, serial number and model number of the NavIC receiver unit at appropriate place, in case it is a proprietary software of the receiver developer. In case no proprietary software is developed as part of the receiver, and a generic open source software is used for testing, the above requirements are not applicable.

5.3 BIS Certification Marking

5.3.1 The NavIC receiver may also be marked with the Standard Mark. The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulation made there under. Details of conditions under which a license for the use of Standard Mark may be granted to manufacturers and producers may be obtained from the Bureau of Indian Standards.

6 TESTING

This section describes the procedures for testing a receiver against the performance requirements mentioned in this document.

6.1 Resource Requirements

Testing the receivers would need hardware and software components that are required to establish a test-setup to provide the input signals required for the test cases and analyze the outputs generated by the DUT (Device Under Test). The following are the basic requirements,

6.1.1 *Hardware requirements*

a) Module under test mounted on evaluation board or customer board
b) Power supply
c) LNA with about 24 to 28 dB gain and < 1.5dB noise figure
d) RF Connectors – SMA/SMB/U.FL as applicable
e) RF Splitter and DC block
f) USB interface cable
g) Laptop
h) High accuracy Oscilloscope
i) Time Interval Counter
j) Signal Generator
k) Low loss RF cables

6.1.2 *Software requirements*

a) GUI from module supplier
b) Receiver UI or general purpose host terminal software (eg. Teraterm)
c) GNSS simulator software

6.1.3 *Documentation requirements*

a) Module / evaluation kit user guide

6.1.4 *Special equipment*

a) Calibrated NavIC + GNSS Multichannel Simulator conforming to NavIC and GNSS ICD

6.2 Test setups

The receiver test setups in general may be classified into two types based on the antenna configuration in the DUT. The two setups would require a GNSS simulator to generate the input test signals. The difference between the two setups would be in the manner by which the signals are fed to the DUT. For the special case of testing the timing performance of the receiver, a separate test setup is required involving a Time Interval Counter (TIC) which is addressed separately.

6.2.1 *TEST SETUP – 1: Conduction mode (Antenna external part of the DUT)*

If the antenna is external to the DUT then the signal source for testing the receiver would be in the form of RF signals fed to the DUT through a low loss RF cable. Refer Fig. 5 and Fig. 6

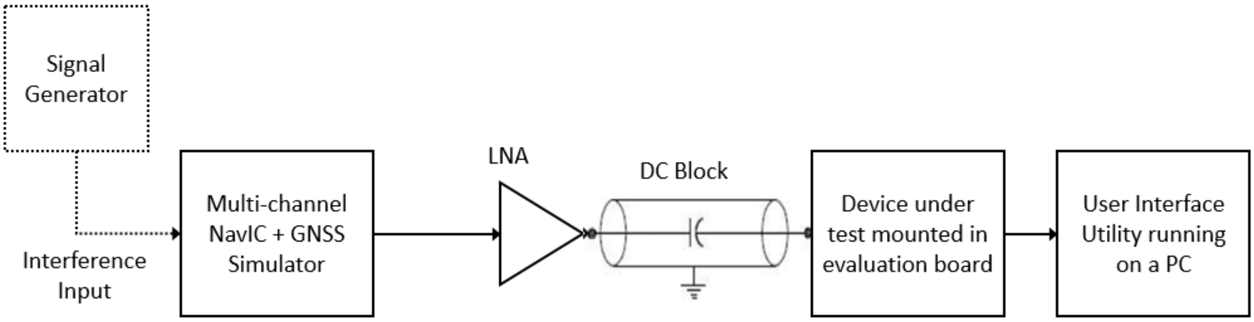

Fig. 5

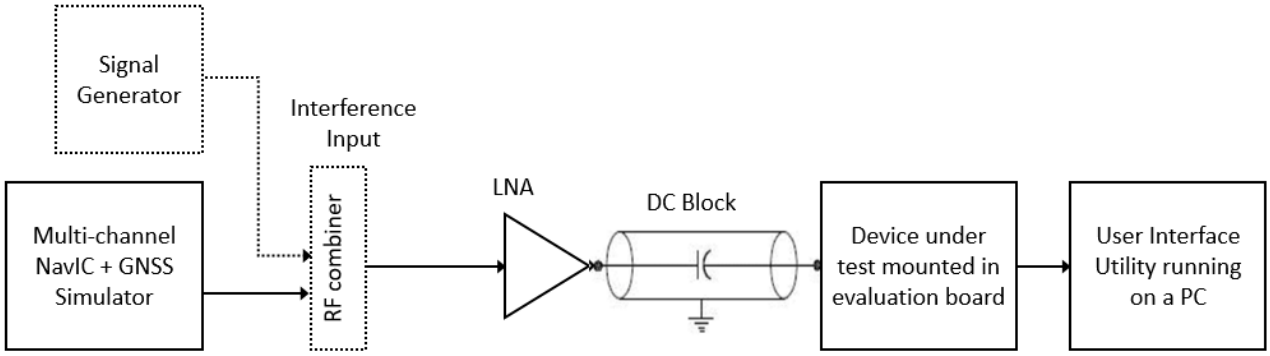

Fig. 6

In the above test setup, the GNSS signals are generated from a multi-channel GNSS simulator (RF output -130dBm nominal power ±20 dB adjustable). The RF output from the simulator is connected to the input of a low noise amplifier through a short RF cable. Both of their insertion loss is calibrated. The output of the LNA is connected to a DC block to prevent the DC bias from the GNSS module from entering the output of the LNA. The output of the DC block is fed to the RF input of the GNSS module under test using another calibrated short RF cable. The data output of the GNSS module is monitored on a PC running a user interface utility provided by the GNSS module developer. For testing the test cases involving interference signals, either of the above two configurations can be chosen depending on if the simulator supports interference input through a dedicated interference input port.

6.2.2 *TEST SETUP – 2: Radiation mode (Antenna internal part of the DUT)*

If the antenna is internal to the DUT then the signal source for testing the receiver would be in the form of radiated RF signals in a well calibrated anechoic chamber. Refer Fig. 7

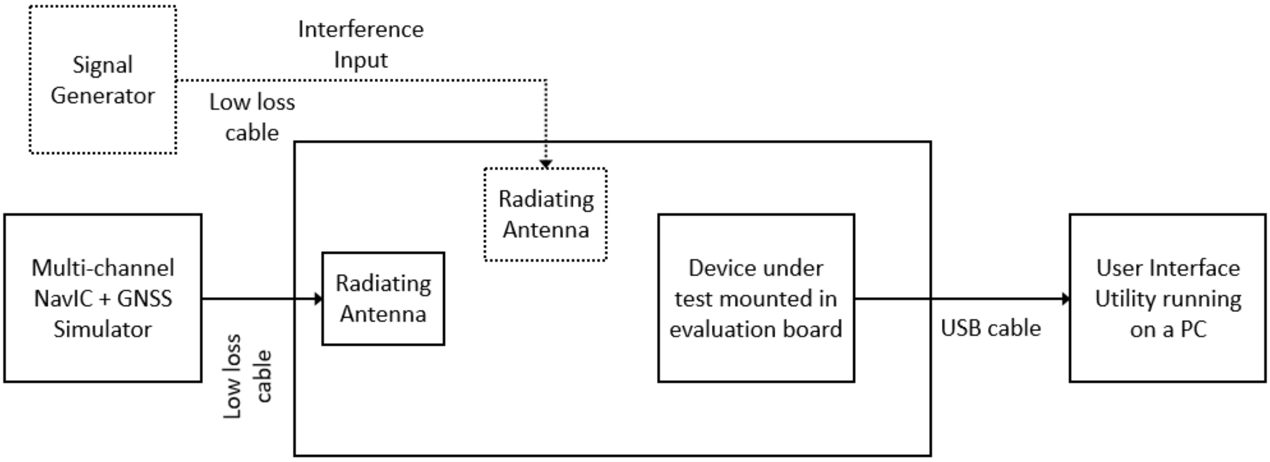

Fig. 7

In the above test setup, the GNSS signals are generated from a multi-channel GNSS simulator (RF output -130dBm nominal power ±20 dB adjustable). The RF output from the simulator is connected to a radiating antenna that supports L1 and L5 bands. The loss of the RF cable as well as the isotropic gain of the antenna shall be well defined / measured. The GNSS module with on-board antenna is placed close to the radiating antenna at a known distance. Both the antenna as well as the receiver under test are placed in an anechoic chamber. The transmission free space path loss of the signal from the radiating antenna to the GNSS module is well calibrated. The data output of the GNSS module is monitored on a PC running a user interface utility provided by the GNSS module developer.

6.2.3 *TEST SETUP – 3: NavIC receiver timing performance test setups*

The testing of timing performance of a NavIC receiver may broadly, be categorized into generic receiver timing performance test case and absolute receiver timing test case. The generic receiver timing performance test case, is a generic test case where the residual errors in the receiver time output is estimated. The absolute time test case is relevant to applications where the absolute time is required, i.e. applications where the alignment of the time output by the receiver to UTC and/or IST is important. This test case is optional and shall be applicable to timing receivers designed specifically for those applications

6.2.3.1 *TEST SETUP – 3(a): Generic NavIC receiver timing performance test setup*

The test setup for testing the generic NavIC receiver timing performance, is given below. The simulator and Time Interval Counter (TIC) are synchronized with a common 10MHz reference signal. The simulator RF output is given as input to the NavIC receiver under test through one of TEST SETUP – 1 or TEST SETUP – 2 depending on the antenna configuration. The simulator 1 PPS output is given as one of the inputs to the TIC while the 1 PPS output of the receiver is given as the other input through calibrated cables. The two 1 PPS signals are compared by the TIC. The comparison data is logged by the TIC on a computer. Refer Fig. 8

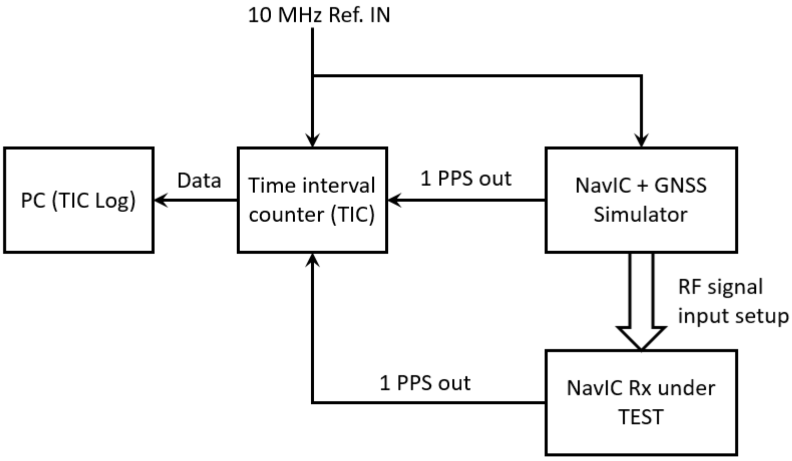

Fig. 8

6.2.3.2 *TEST SETUP – 3(b): Absolute NavIC receiver time test setup (optional)*

The test setup for testing the absolute NavIC receiver time is given below. To carry out this test, a UTC (NPLI) source is required, as such it can only be performed at National Physics Laboratory (NPL), Delhi facility or a testing lab/facility which has a time source that is calibrated against UTC (NPLI). The setup consists of a TIC that is synchronized to the UTC (NPLI) source. The TIC is given a 1 PPS signal from the UTC (NPLI) source as an input through a calibrated cable. The 1 PPS signal from the NavIC receiver is given to the TIC as the other input through a calibrated cable. The receiver setup will be such that it will receive the GNSS signals under open sky conditions. The two 1 PPS signals are compared by the TIC. The comparison data is logged by the TIC on a computer. Refer Fig. 9

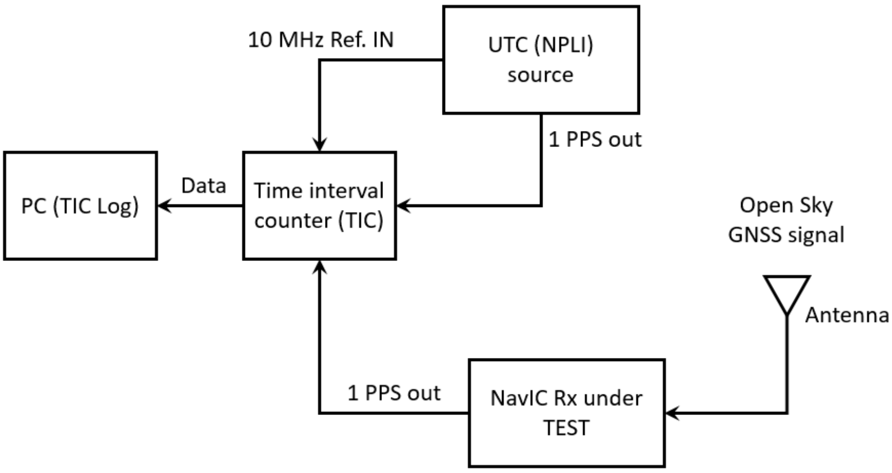

Fig. 9

6.2.4 *NavIC + GNSS Simulator Test Scenarios*

To carry out testing of the DUT, the GNSS simulator shall be configured with scenarios appropriate for the test cases. For the purpose of covering all the test cases in this document, two types of simulator test scenarios are defined.

6.2.4.1 *STATIC_SCENARIO*

The simulator shall be configured with the standard NavIC satellite constellation with NavIC SPS L1, L5 and S band signals as mentioned in the ICDs. The appropriate ionospheric and tropospheric models are configured as per the ICDs. The receiver is configured to be stationary with an isotropic antenna located at a pre-defined latitude, longitude and altitude in the NavIC coverage region.

6.2.4.2 *DYNAMIC_SCENARIO*

The simulator shall be configured with the standard NavIC satellite constellation with NavIC SPS L1, L5 and S band signals as mentioned in the ICDs. The appropriate ionospheric and tropospheric models are configured as per the ICDs. The receiver shall be configured with an isotropic antenna. The receiver dynamics shall be configured in the simulator as per the following three trajectories.

A. **Circular Motion:** The simulator shall be configured with a circular motion trajectory for the receiver. The personality file of the simulator shall be set to not exceed the limits of 515 m/s velocity, 40 m/s^2 acceleration and 5 m/s^3 jerk. In the trajectory settings, the center of the circle shall be configured with [Latitude, Longitude, Altitude] parameters corresponding to the test facility (preferably, or it can be configured to Bangalore [12.9716° N, 77.5946° E, 1000m] which is approximately at the center of the coverage). The radius of the circle shall be 5000m, with the receiver's initial bearing 90° E and a constant tangential speed of 25 m/s. The receiver shall keep following this trajectory for the full duration of the simulator scenario. This is the most generic trajectory for the receiver under dynamics. A pictorial representation of the settings is given in Fig. 10 below.

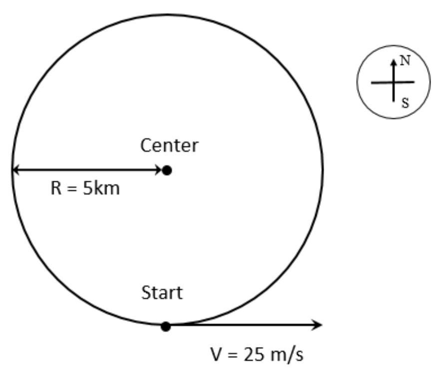

Fig. 10

B. **Rectilinear Motion:** The simulator shall be configured with a rectilinear motion trajectory for the receiver. The personality file of the simulator shall be set to not exceed the limits of 515 m/s velocity, 40 m/s^2 acceleration and 5 m/s^3 jerk. The starting point of the receiver shall be configured to be [Latitude, Longitude, Altitude] parameters corresponding to the test facility (preferably, or it can be configured to Bangalore [12.9716° N, 77.5946° E, 1000m] which is approximately at the center of the coverage). The initial heading of the receiver shall be 90° E with a constant speed of 515 m/s for a duration of 20s. The receiver shall then make a 90° right turn and continue with the same speed for a duration of 20s and so on. The receiver shall follow the trajectory as given below perpetually for the full duration of the simulator scenario. This trajectory shall, mainly be used for testing the velocity accuracy of the receiver and some test cases for where the maximum Doppler supported by the receiver is of importance. Refer Fig. 11 below.

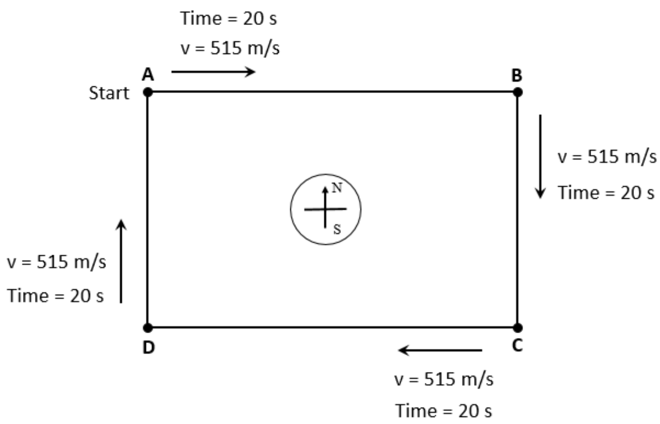

Fig. 11

C. **Linear Motion:** The simulator shall be configured with a linear motion trajectory for the receiver. The personality file of the simulator shall be set, to not exceed the limits of 40 m/s^2 acceleration and 5 m/s^3 jerk. The starting point of the receiver shall be configured to be [Latitude, Longitude, Altitude] parameters corresponding to the test facility (preferably, or it can be configured to Bangalore [12.9716° N, 77.5946° E, 1000m] which is approximately at the center of the coverage). The receiver's initial heading can be chosen by the tester, (in the representative diagram it is chosen as 90° E). The receiver shall start with no initial acceleration and a constant velocity of 1 m/s. This shall persist for a period of 120s. Following this, the acceleration of the receiver shall keep increasing at a rate of 5 m/s^3 till it reaches an acceleration of 35 m/s^2. In the next second, its acceleration shall reach the maximum of 39.2 m/s^2 and continue at that acceleration for a period of 5s following which the scenario shall reach an end. This scenario is targeted at testing the receiver for the maximum acceleration tolerance of 4g. The representative diagram of the trajectory is given in Fig. 12 below.

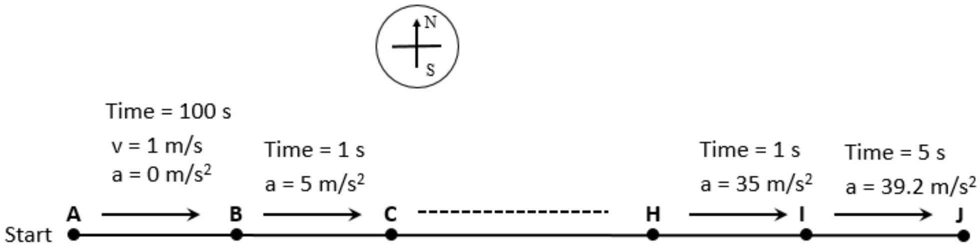

Fig. 12

6.3 Test cases

6.3.1 *Test case for DUT on NavIC signal support capability*

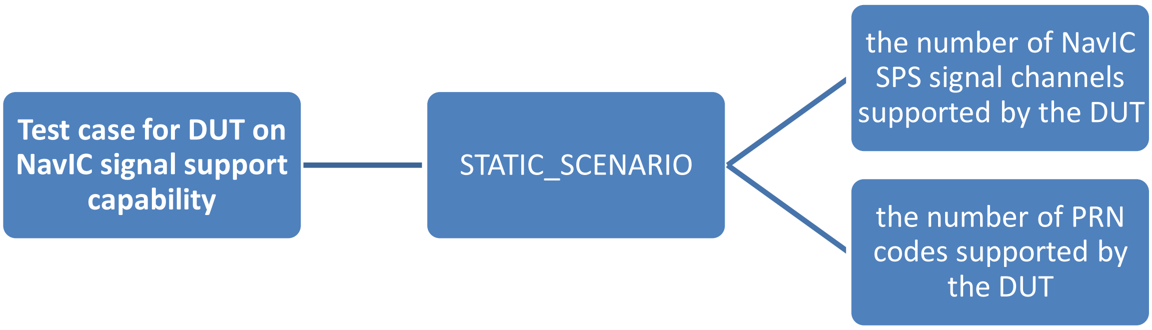

Fig. 13

Test Case ID	**TID-1**
Brief Description	To check the number of NavIC SPS signal channels supported by the DUT
Inputs	Run a static scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses.
Expected Output	The DUT GUI should show tracking of • ≥ 7 channels of L1 band signals • ≥ 7 channels of L5 band signals • ≥ 7 channels of S signals
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO

Test Case ID	**TID-2**
Brief Description	To check the number of PRN codes supported by the DUT
Inputs	Run a static scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. The simulator shall be set to output the satellite PRN codes in sets of 7 to cover all the PRN codes mentioned in the SIS ICDs of the respective frequency bands.
Expected Output	The DUT GUI should show tracking of 7 NavIC satellites each time the fresh 7 sets of PRN codes are configured in the simulator.
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO

6.3.2 *Test case for DUT on its sensitivity*

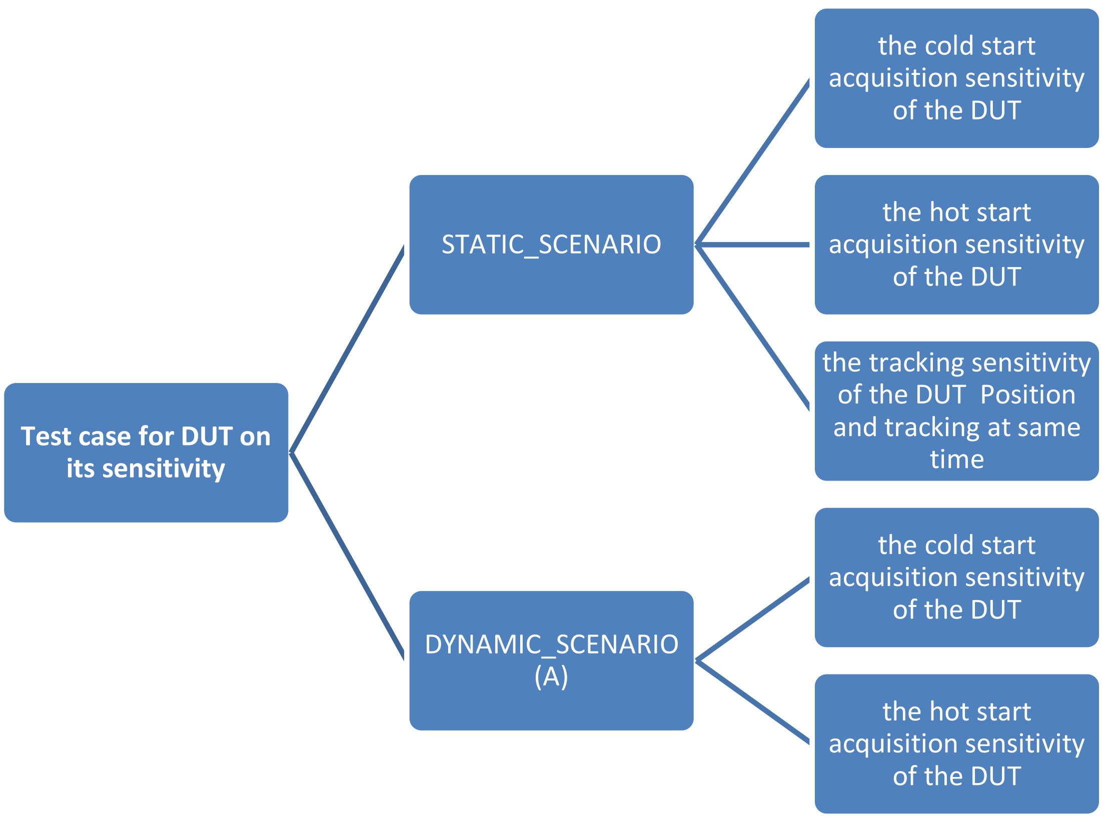

Fig. 14

Test Case ID	**TID-3**
Brief Description	To check the cold start acquisition sensitivity of the DUT
Inputs	Run a scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –142 dBm including the total signal chain losses. Remove the voltage source for battery backed memory/RTC and/or clear the contents of the non-volatile memory of the DUT. Turn ON the DUT and verify if it is able to acquire all the visible satellites and compute a position fix
Expected Output	The DUT should acquire satellites at -142 dBm and provide a position fix within 5 minutes
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO and DYNAMIC_SCENARIO (A)

Test Case ID	**TID-4**
Brief Description	To check the hot start acquisition sensitivity of the DUT
Inputs	Run a scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. Turn ON the DUT and allow it to lock (track) all visible satellites, collect ephemeris, almanac, time and position data. Turn OFF the DUT and reduce the signal strength on the simulator such that the signal power at the RF port / antenna of the DUT is -150 dBm. Turn ON the DUT and verify if it is able to acquire all the visible satellites and compute a position fix.
Expected Output	The DUT should acquire satellites at -150 dBm under the hot start mode and provide a position fix within 1 minute
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO and DYNAMIC_SCENARIO (A)

Test Case ID	**TID-5**
Brief Description	To check the tracking sensitivity of the DUT
Inputs	Run a scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. Turn ON the DUT and allow it to lock/track all visible satellites and compute position. Reduce the satellite signal strength in steps of 1dB at a time with a 5s gap between each step. Verify the lock/tracking status of all the satellites and position availability at each step.
Expected Output	The DUT shall maintain lock/tracking of all visible satellites at -156dBm and compute position.
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO

6.3.3 *Test case for DUT on its accuracy*

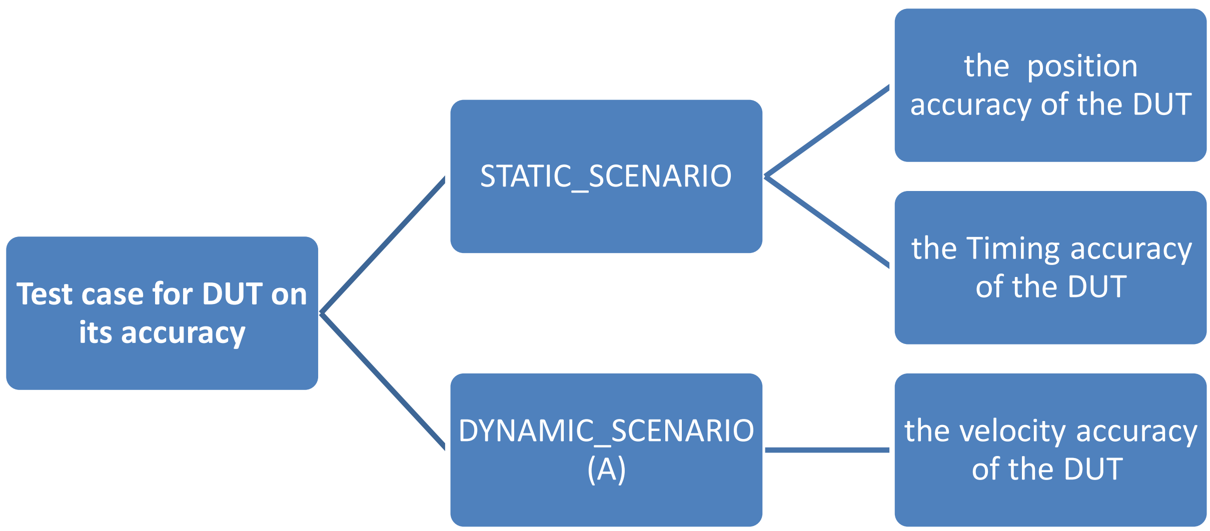

Fig. 15

Test Case ID	**TID-6**
Brief Description	To check the 3-D RMS position accuracy of the DUT
Inputs	Run a scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. Turn ON the DUT, and allow it to lock (track) the satellites and compute position. Disable features that modify location like static hold, static navigation, etc. Record the receiver location configured in the simulator. Collect the position output log of the DUT for a minimum of 30 mins at 1Hz measurement rate.
Expected Output	Compute the CEP, SEP and RMS (3D) position errors using the configured receiver location in the simulator and the DUT position output measurements. The CEP shall be less than or equal to 10m, SEP shall be less than or equal to 20m and RMS (3D) position error shall be less than or equal to 20m.
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO

Test Case ID	**TID-7**
Brief Description	To check the velocity accuracy of the DUT
Inputs	Run a scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. Configure the receiver to have a 30 m/s constant velocity. Turn ON the DUT, and allow it to lock (track) the satellites and compute position. Collect the velocity output log of the DUT for a minimum of 30mins at 1Hz measurement rate.

Expected Output	Compute the difference between the configured receiver velocity (ground trace) in the simulator and the DUT velocity output measurements (ground trace as reported in NMEA output). The RMS value of the difference should be less than or equal to 0.1 m/s
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup shall be as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	DYNAMIC_SCENARIO (A)

Test Case ID	**TID-8**
Brief Description	To check the Timing accuracy of the DUT
Inputs	Run a static scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. Turn ON the DUT, and allow it to lock (track) the satellites and compute position. Observe the time interval counter log, and calculate the RMS value of the offset between the 1 PPS outputs.
Expected Output	The RMS value of the offset between the 1PPS outputs shall be less than or equal to 50ns.
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup shall be as per 6.2.3.1 with appropriate simulator to receiver setup (6.2.1 or 6.2.2) depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO

Test Case ID	**TID-9**
Brief Description	To check the absolute time accuracy of the DUT in comparison to IST (UTC_{NPLI})
Inputs	Set up the DUT antenna with an open sky signal view. Turn ON the DUT and, allow it to lock (track) the satellites and compute position. Log the measurements of the time interval counter taking inputs from the 1 PPS output of the NavIC receiver and 1 PPS output from a UTC_{NPLI} source (at either NPL or any other certified laboratory) for a period of 24 hours.

Expected Output	Average offset between 1pps (DUT) and UTC(NPLI) shall be below 40ns and the standard deviation of all measurements shall be less than 20ns.
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT. This is an optional test case designed for calibration of NavIC timing receivers. This test case is not applicable to all NavIC receivers.
Test Setup	Test setup as per 6.2.3.2
Simulator Scenario	Simulator is not used in this test case

6.3.4 *Test case for DUT on its capability to handle receiver dynamics*

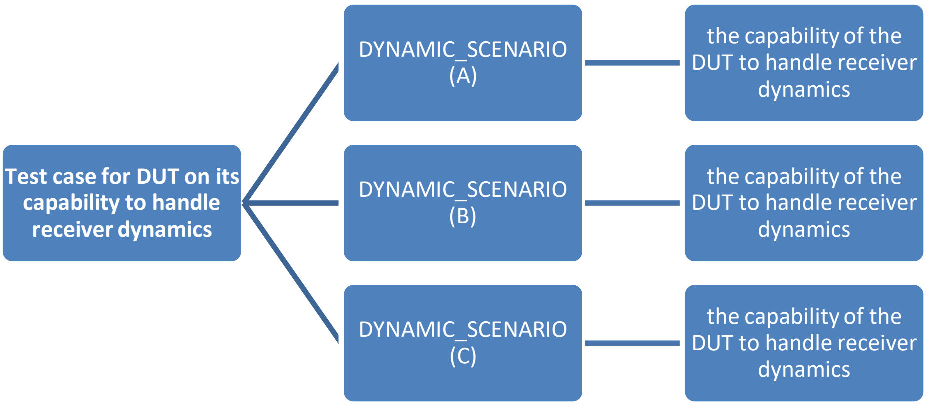

Fig. 16

Test Case ID	**TID-10**
Brief Description	To check the capability of the DUT to handle receiver dynamics
Inputs	Run the dynamic scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. Turn ON the DUT and, allow it to lock (track) the satellites and compute position. Log the position and velocity outputs for a duration of 1 hour/ duration of the simulator scenario, from both the DUT and the Simulator. Observe the 1PPS outputs of the simulator and the DUT using an oscilloscope. Compare the logs of the DUT output versus the log of the simulator.
Expected Output	The receiver shall follow the simulated dynamics without losing track of any satellites. The position of the DUT shall be within 20m of the simulator log. The velocity (ground trace) of the DUT shall be within 0.1 m/s of the simulator log.

Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT. The simulator scenarios shall cover all the trajectories under DYNAMIC_SCENARIO
Test Setup	Test setup shall be as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	DYNAMIC_SCENARIO (A), DYNAMIC_SCENARIO (B), DYNAMIC_SCENARIO (C)

6.3.5 Test case for DUT on its input signal power dynamic range

Fig. 17

Test Case ID	**TID-11**
Brief Description	To check the DUT's capability to handle input signal power dynamic range
Inputs	Run a static scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. Turn ON the DUT, and allow it to lock (track) the satellites and compute position. Increase the signal power of one satellite in the simulator from -130 dBm to -124 dBm. Reduce the signal power of one satellite in the simulator from -130 dBm t0 -142 dBm. Wait for the DUT to acquire and track all the visible satellites and compute position. Turn OFF and Turn ON the DUT
Expected Output	The DUT shall be able to acquire and track all the visible NavIC satellites within 5 minutes. The DUT shall be able to re-acquire and track all the visible NavIC satellites after it is turned OFF and turned ON
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup shall be as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO

6.3.6 *Test case for DUT on its TTFF*

Fig. 18

Test Case ID	**TID-12**
Brief Description	To check the DUT's cold-start TTFF
Inputs	Run a static scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. 1. Remove the voltage source for battery backed memory/RTC and/or clear the contents of the non-volatile memory of the DUT. 2. Turn ON the DUT and note the time taken for the first position fix with a minimum of 4 satellites tracked. 3. Turn OFF the DUT Repeat the steps 1, 2 & 3 for 10 times
Expected Output	The time taken by the DUT to output the first position fix should be better than 120s for DUTs without L1 signal support for at least 9 out of the 10 repetitions The time taken by the DUT to output the first position fix should be better than 60s for DUTs with L1 signal support for at least 9 out of the 10 repetitions
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup shall be as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO

Test Case ID	**TID-13**
Brief Description	To check the DUT's hot-start TTFF

Inputs	Run a static scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. 1. Turn ON the DUT and allow it to lock (track) all visible satellites, collect ephemeris, almanac, time and position data. 2. Turn OFF the DUT 3. Turn ON the DUT note the time taken for the first position fix with a minimum of 4 satellites tracked. 4. Turn OFF the DUT Repeat the steps 1, 2, 3 &4 for 10 times
Expected Output	The time taken by the DUT to output the first position fix shall be better than 5 s for at least 9 out of the 10 repetitions
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup shall be as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO

6.3.7 *Test case for DUT on its robustness to interference*

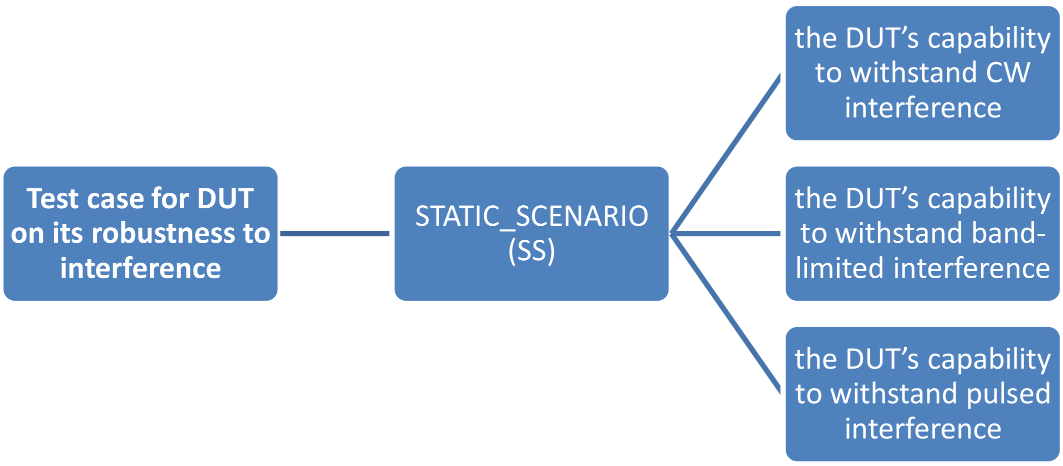

Fig. 19

Test Case ID	**TID-14**
Brief Description	To check the DUT's capability to withstand CW interference

Inputs	Run a static scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. Connect the signal generator to the simulator external interference port. In case the simulator does not support the interference port, combine the signal generator output with the simulator output before feeding it to the LNA or radiating antenna. Select 10 points on the CW interference threshold plots for each of the supported RF frequency bands to choose 10 interference signal power and frequency pairs distributed across the frequency band. 1. Turn ON the DUT and wait for the satellite signals to be tracked and the satellite C/N_0 to be logged. 2. Configure the signal generator to introduce the CW interference signal for one interference signal power and corresponding frequency pair. 3. Turn ON the signal generator output and observe the degradation in the C/N_0 of the satellites for 1 min 4. Repeat steps 2 and 3 till all 10 pairs are checked.
Expected Output	The degradation in C/N_0 of the satellites due to introduction of the CW interference shall not be more than 1 dB. The test shall be conducted for all the frequency bands supported by the DUT
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup shall be as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO

Test Case ID	**TID-15**
Brief Description	To check the DUT’s capability to withstand band-limited interference

Inputs	Run a static scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. Connect the signal generator to the simulator external interference port. In case the simulator does not support the interference port, combine the signal generator output with the simulator output before feeding it to the LNA or radiating antenna. Select 10 points on the interference bandwidth vs. interference threshold plot to choose 10 interference signal power and bandwidth pairs. 1. Turn ON the DUT and wait for the satellite signals to be tracked and the satellite C/N_0 to be logged. 2. Configure the signal generator to introduce the band-limited interference signal for one interference signal power and corresponding bandwidth pair. The center frequency shall be selected such that the band-limited interference signal is within the pass band of the DUT but the interference threshold shall not exceed -138dBW/MHz in the signal bandwidth i.e. L5 (1176.45 MHz ± 12 MHz), L1 (1575.42 MHz ± 12 MHz) and S Band (2492.028 MHz ± 8.25 MHz). 3. Turn ON the signal generator output and observe the degradation in the C/N_0 of the satellites for 1 min 4. Repeat steps 2 and 3 till all 10 pairs are checked.
Expected Output	The degradation in C/N_0 of the satellites due to introduction of the band-limited interference shall not be more than 1 dB. The test shall be conducted for all the frequency bands supported by the DUT
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup shall be as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO

Test Case ID	**TID-16**
Brief Description	To check the DUT's capability to withstand pulsed interference

Inputs	Run a static scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. Connect the signal generator to the simulator external interference port. In case the simulator does not support the interference port, combine the signal generator output with the simulator output before feeding it to the LNA or radiating antenna. Turn ON the DUT and wait for the satellite signals to be tracked and the satellite C/N_0 to be logged. Configure the signal generator to introduce the pulsed interference signal in the pass band of the DUT with 3µs pulse width, -20dBm pulse peak power and 10% pulse duty cycle. Turn ON the signal generator output and observe the degradation in the C/N_0 of the satellites for 1 min
Expected Output	The degradation in C/N_0 of the satellites due to introduction of the pulsed interference shall not be more than 1 dB. The test shall be conducted for all the frequency bands supported by the DUT
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT
Test Setup	Test setup shall be as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO

6.3.8 *Test case for DUT on its output formats*

Fig. 20

Test Case ID	**TID-17**
Brief Description	To check the DUT's output format
Inputs	Run a static scenario with NavIC L1/L5/S band support on the multi-channel NavIC + GNSS simulator with the satellite signal levels set to a value such that the signal power at the RF port / antenna of the DUT is at –130 dBm including the total signal chain losses. Turn ON the DUT and collect the output log of the DUT for 5 min.
Expected Output	The output of the DUT shall be in NMEA 0183 v4.10 or later format updated at the specified rate by the manufacturer.
Special Instructions	The frequency bands simulated shall be as per the RF bands claimed to be supported by the DUT

Test Setup	Test setup shall be as per 6.2.1 or 6.2.2 depending upon the module configuration
Simulator Scenario	STATIC_SCENARIO

7 OPERATING LIFE TEST

The NAVIC receiver shall be subjected to operating life test while receiving signal via the antenna or the simulator. The test shall consist of 48h of operation at 1.1 times of upper voltage of Input voltage range (declared by the manufacturer) and at a temperature of 45 ºC. For supply voltage and temperature to be maintained during the test, tolerance of ± 5 % is allowed.

The NAVIC Receiver shall be considered to have failed the test:

a) if there is loss of signal longer than 5 seconds; or
b) if the NavIC Receiver reboots or is non-responsive at the end of the test.

At the end of the operating life test duration, the requirements specified in Table 1 shall also be met with.

Table 1 Specifications
(*Clause* 4)

<table>
<tr><th>Sl No.
(1)</th><th>Parameter ID
(2)</th><th>Mandatory Specification
(3)</th><th>Optional Specification
(4)</th><th>Compliance and Test Method(s)
(5)</th></tr>
<tr><td>i)</td><td colspan="4">Receiver NavIC SPS signal support capability</td></tr>
<tr><td></td><td>Parameter ID
ID – 1
ID – 2</td><td><table><tr><td>Parameter</td><td>Signal</td><td>For each frequency</td></tr><tr><td>Number of channels</td><td>NavIC SPS (L1, L5, S)</td><td>≥ 7</td></tr><tr><td>Number of PRN codes</td><td>NavIC SPS (L1, L5, S)</td><td>14</td></tr></table></td><td>—</td><td>Compliance is checked by Inspection/ Clause 5</td></tr>
<tr><td>ii)</td><td colspan="4">Cold-start acquisition sensitivity</td></tr>
<tr><td></td><td>Parameter ID
ID – 3</td><td><table><tr><td>Parameter</td><td>Signal</td><td>Signal strength</td></tr><tr><td>Cold-start acquisition sensitivity</td><td>NavIC SPS (L1, L5, S)</td><td>-142 dBm</td></tr></table></td><td>—</td><td>Compliance is checked by Inspection/ To Discuss/ Clause 5</td></tr>
<tr><td>iii)</td><td colspan="4">Hot-start acquisition sensitivity</td></tr>
<tr><td></td><td>Parameter ID
ID – 4</td><td><table><tr><td>Parameter</td><td>Signal</td><td>Signal strength</td></tr><tr><td>Hot-start acquisition sensitivity</td><td>NavIC SPS (L1, L5, S)</td><td>-150 dBm</td></tr></table></td><td>—</td><td>Compliance is checked by Inspection/To Discuss/ Clause 5</td></tr>
<tr><td>iv)</td><td colspan="4">Tracking sensitivity</td></tr>
<tr><td></td><td>Parameter ID
ID – 5</td><td><table><tr><td>Parameter</td><td>Signal</td><td>RMS value</td></tr><tr><td>Tracking sensitivity</td><td>NavIC SPS (L1, L5, S)</td><td>-156 dBm</td></tr></table></td><td></td><td>Compliance is checked by Inspection/To Discuss/ Clause 5</td></tr>
<tr><td>v)</td><td colspan="4">Receiver accuracy</td></tr>
<tr><td></td><td>Parameter ID
ID – 6
ID – 7
ID – 8</td><td><table><tr><td>Parameter</td><td>Signal</td><td>value</td></tr><tr><td>position accuracy</td><td>NavIC SPS (L1, L5, S)</td><td>CEP ≤ 10 m
SEP ≤ 20 m
RMS (3D) ≤ 20 m</td></tr><tr><td>velocity accuracy</td><td>NavIC SPS (L1, L5, S)</td><td>RMS : 0.1 m/s</td></tr><tr><td>Time accuracy</td><td>NavIC SPS (L1, L5, S)</td><td>RMS : 50 ns</td></tr></table></td><td>Absolute time accuracy (NavIC SPS (L1, L5, S))
Mean: 40 ns
σ : 20 ns</td><td>Compliance is checked by Inspection/To Discuss/ Clause 5</td></tr>
</table>

<table>
<tr><th>Sl No.
(1)</th><th>Parameter ID
(2)</th><th>Mandatory Specification
(3)</th><th>Optional Specification
(4)</th><th>Compliance and Test Method(s)
(5)</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>vi)</td><td colspan="4">Receiver dynamics
(Minimum required NavIC receiver motion tolerance)</td></tr>
<tr><td></td><td><table><tr><td>Parameter ID</td></tr><tr><td>ID – 9 a</td></tr><tr><td>ID – 9 b</td></tr></table></td><td><table><tr><th>Parameter</th><th>Signal</th><th>At least up to</th></tr><tr><td>Receiver velocity</td><td>NavIC SPS (L1, L5, S)</td><td>515 m/s</td></tr><tr><td>Receiver acceleration</td><td>NavIC SPS (L1, L5, S)</td><td>4g m/s2</td></tr></table></td><td>—</td><td>Compliance is checked by Inspection/To Discuss/ Clause 5</td></tr>
<tr><td>vii)</td><td colspan="4">Receiver input signal power dynamic range
(Minimum required NavIC receiver input signal power dynamic range)</td></tr>
<tr><td></td><td><table><tr><td>Parameter ID</td></tr><tr><td>ID – 10</td></tr></table></td><td><table><tr><th>Parameter</th><th>Signal</th><th>Signal strength</th></tr><tr><td>Receiver input signal power dynamic range</td><td>NavIC SPS (L1, L5, S)</td><td>18 dB</td></tr></table></td><td>—</td><td>Compliance is checked by Inspection/To Discuss/ Clause 5</td></tr>
<tr><td>viii)</td><td colspan="4">Cold-start TTFF
(Minimum required NavIC receiver cold-start TTFF)</td></tr>
<tr><td></td><td><table><tr><td>Parameter ID</td></tr><tr><td>ID – 11 a</td></tr><tr><td>ID – 11 b</td></tr></table></td><td><table><tr><th>Parameter</th><th>Signal</th><th>90% probable</th></tr><tr><td>Cold-start TTFF</td><td>NavIC SPS (L5, S)</td><td>< 120 s</td></tr><tr><td>Cold-start TTFF</td><td>NavIC SPS (L1)</td><td>< 60 s</td></tr></table></td><td>—</td><td>Compliance is checked by Inspection/To Discuss/ Clause 5</td></tr>
<tr><td>ix)</td><td colspan="4">Hot-start TTFF
(Minimum required NavIC receiver hot-start TTFF)</td></tr>
<tr><td></td><td><table><tr><td>Parameter ID</td></tr><tr><td>ID – 12</td></tr></table></td><td><table><tr><th>Parameter</th><th>Signal</th><th>90% probable</th></tr><tr><td>Cold-start TTFF</td><td>NavIC SPS (L1, L5, S)</td><td>< 5 s</td></tr></table></td><td>—</td><td>Compliance is checked by Inspection/To Discuss/ Clause 5</td></tr>
<tr><td>x)</td><td colspan="4">CW interference located in-band and near-band
(Maximum allowable C/N_0 degradation under CW interference)</td></tr>
<tr><td></td><td><table><tr><td>Parameter ID</td></tr><tr><td>ID – 13</td></tr></table></td><td><table><tr><th>Parameter</th><th>Signal</th><th>Degradation</th></tr></table></td><td>—</td><td>Compliance is checked by Inspection/To</td></tr>
</table>

Sl No. (1)	**Parameter ID** (2)	**Mandatory Specification** (3)	**Optional Specification** (4)	**Compliance and Test Method(s) (5)**
		C/N_0 change due to interference / NavIC SPS (L1, L5, S) / ≤ 1 dB		Discuss/ Clause 5
a)	CW interference thresholds for NavIC L5 band receivers in steady-state navigation			
	See table a) below			Compliance is checked by Inspection/To Discuss/ Clause 5
b)	CW interference thresholds for NavIC S band receivers in steady-state navigation			
	See table b) below			Compliance is checked by Inspection/To Discuss/ Clause 5
c)	**CW interference thresholds for NavIC L1 band receivers in steady-state navigation**			
	See table c) below			Compliance is checked by Inspection/To Discuss/ Clause 5
xi)	**Band-limited noise-like interference** (Maximum allowable C/N_0 degradation under band-limited noise-like interference)			

C/N_0 change due to interference	NavIC SPS (L1, L5, S)	≤ 1 dB

a)

Frequency range (fi) of the interference signal	Interference thresholds for receivers in steady-state navigation
fi ≤ 935 MHz	–20 dBW
935 MHz < fi ≤ 1135 MHz	–20 dBW to –60 dBW
1135 MHz < fi ≤ 1164.45 MHz	–60 dBW to –138 dBW
1164.45 MHz < fi ≤ 1188.45 MHz	–138 dBW
1188.45 MHz < fi ≤ 1220 MHz	–138 dBW to –60 dBW
1220 MHz < fi ≤ 1420 MHz	–60 dBW to –20 dBW
fi > 1420 MHz	–20 dBW

b)

Frequency range (fi) of the interference signal	Interference thresholds for receivers in steady-state navigation
fi ≤ 2260 MHz	–20 dBW
2260 MHz < fi ≤ 2460 MHz	–20 dBW to –60 dBW
2460 MHz < fi ≤ 2483.5 MHz	–60 dBW to –138 dBW
2483.5 MHz < fi ≤ 2500 MHz	–138 dBW
2500 MHz < fi ≤ 2530 MHz	–138 dBW to –60 dBW
2530 MHz < fi ≤ 2730 MHz	–60 dBW to –20 dBW
fi > 2730 MHz	–20 dBW

c)

Frequency range (fi) of the interference signal	Interference thresholds for receivers in steady-state navigation
fi ≤ 1335 MHz	–20 dBW
1335 MHz < fi ≤ 1535 MHz	–20 dBW to –60 dBW
1535 MHz < fi ≤ 1 563.42 MHz	–60 dBW to –138 dBW
1 563.42 MHz < fi ≤ 1 587.42 MHz	–138 dBW
1 587.42 MHz < fi ≤ 1615 MHz	–138 dBW to –60 dBW
1615 MHz < fi ≤ 1815 MHz	–60 dBW to –20 dBW
fi > 1815 MHz	–20 dBW

Sl No. (1)	**Parameter ID** (2)	**Mandatory Specification** (3)	**Optional Specification** (4)	**Compliance and Test Method(s)** **(5)**
	Parameter ID ID – 14	<table><tr><td>Parameter</td><td>Signal</td><td>Degradation</td></tr><tr><td>C/N_0 change due to interference</td><td>NavIC SPS (L1, L5, S)</td><td>≤ 1 dB</td></tr></table>	—	Compliance is checked by Inspection/To Discuss
a)	Interference threshold for band-limited noise-like interference to NavIC receivers in steady-state navigation			
	<table><tr><td>Interference bandwidth (BW)</td><td>Interference threshold for receivers in steady state navigation*</td></tr><tr><td>0 Hz < BW ≤ 700 Hz</td><td>–144 dBW</td></tr><tr><td>10 kHz</td><td>–141 dBW</td></tr><tr><td>100 kHz</td><td>–138 dBW</td></tr><tr><td>100 kHz < BW ≤ 1 MHz</td><td>–138 dBW</td></tr><tr><td>20 MHz</td><td>–125 dBW</td></tr><tr><td>BW ≥ 24 MHz</td><td>–120 dBW</td></tr><tr><td colspan="2">* The interference threshold shall not exceed –138dBW/MHz in the frequency range L5 (1176.45 MHz ± 12 MHz) , L1 (1575.42 MHz ± 12 MHz) and S Band (2492.028 MHz ± 8.25 MHz).</td></tr></table>			Compliance is checked by Inspection/To Discuss/ Clause 5
xii)	**Pulsed interference** (Maximum allowable C/N_0 degradation under pulsed interference)			
	Parameter ID ID – 15	<table><tr><td>Parameter</td><td>Signal</td><td>Degradation</td></tr><tr><td>C/N_0 change due to interference</td><td>NavIC SPS (L1, L5, S)</td><td>≤ 1 dB</td></tr></table>	—	Compliance is checked by Inspection/To Discuss
a)	**Interference threshold for pulsed interference to NavIC receivers in steady-state navigation**			
	<table><tr><td>Characteristic</td><td>Value</td></tr><tr><td>Frequency range L5 band</td><td>1 164.45 MHz to 1 188.45 MHz</td></tr><tr><td>Frequency range L1 band</td><td>1 563.42 MHz to 1 587.42 MHz</td></tr><tr><td>Frequency range S band</td><td>2 483.50 MHz to 2 500.00 MHz</td></tr><tr><td>Interference threshold (pulse peak power)</td><td>–20 dBm</td></tr><tr><td>Pulse width</td><td>≤ 1 ms</td></tr><tr><td>Pulse duty cycle</td><td>≤ 10 %</td></tr><tr><td>Signal bandwidth</td><td>≥ 2 MHz</td></tr><tr><td colspan="2">NOTE — The signal bandwidth specifies the minimum bandwidth of the noise-like signal with a power as large as the interference threshold that is pulsed with the specified pulse width and duty cycle.</td></tr></table>			Compliance is checked by Inspection/To Discuss/ Clause 5
xiii)	**Receiver output formats**			
	Parameter ID ID – 16	<table><tr><td>Parameter</td><td>Signal</td><td>Standard</td></tr><tr><td>Supported data format</td><td>NavIC SPS (L1, L5, S)</td><td>NMEA 0183 v4.10 or later</td></tr></table>	—	Compliance is checked by Inspection/To Discuss