Development of NavIC Payload Signal Integrity & Coherency Test Receiver: Configurable for all GNSS Modulations

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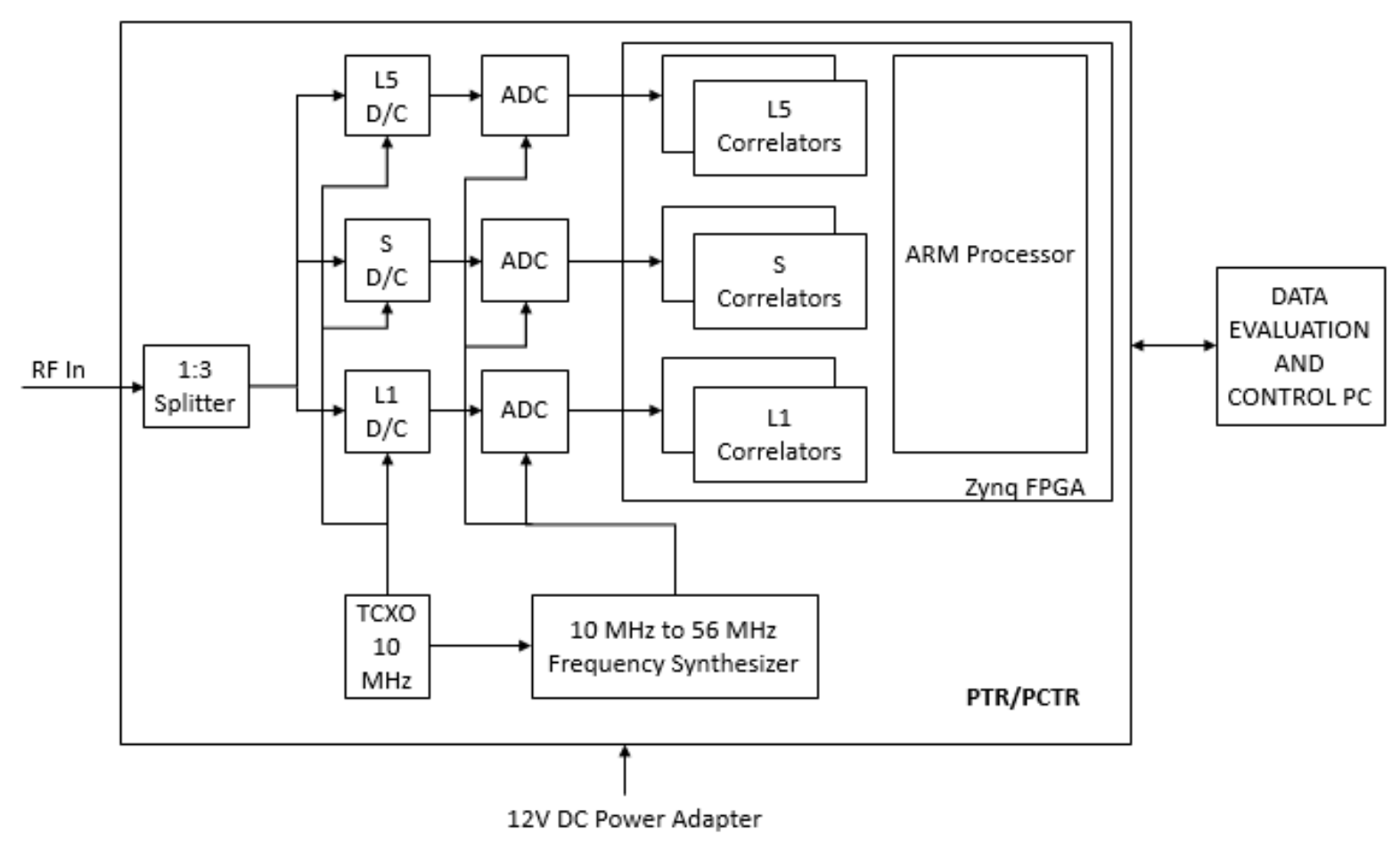
Overview

- Navigation signal data integrity and code-carrier phase coherency between various signal components are of paramount importance for the efficient performance of the satellite navigation system.
- Special Class of Configurable Receiver is developed to evaluate data integrity and coherency parameters for the checkout of the NavIC payloads and satellites.
- This receiver is also used during In-Orbit Testing of the satellite as well as in Signal Monitoring Stations for NavIC.
- The receiver firmware is also configurable for the processing of various other open GNSS signals with variety of modulation schemes and data formats.

Salient Features

S. No.	Parameter	Specifications
1	Frequency Band	L5 (1176.45 MHz), L1 (1575.42 MHz), S (2492.028 MHz)
3	RF Bandwidth	24 MHz
4	Number of channels	26 Channels
5	Signal reception Capability	All IRNSS Signals in L1, L5 and S Band Configurable for open GNSS L1 Signals
6	Supported Modulation Schemes	BPSK (m) BOC (m,n) Multiplexed BOC (SBOC, CBOC etc.)
7	Output Data update rate	1 Hz
8	Output Data	Code Phase, Carrier Phase, Estimated Received signal Strength, Navigation Message after FEC Decoding
9	Code and Carrier Phase measurement precision	Within 10% of theoretical limits
10	Coherency Measurements (Inter and Intra Frequency Band)	Code-Code Coherency: 4 mm (13 ps) Code-Carrier Coherency: 3 mm (10 ps) Carrier-Carrier Coherency: 1 mm (3.33 ps)

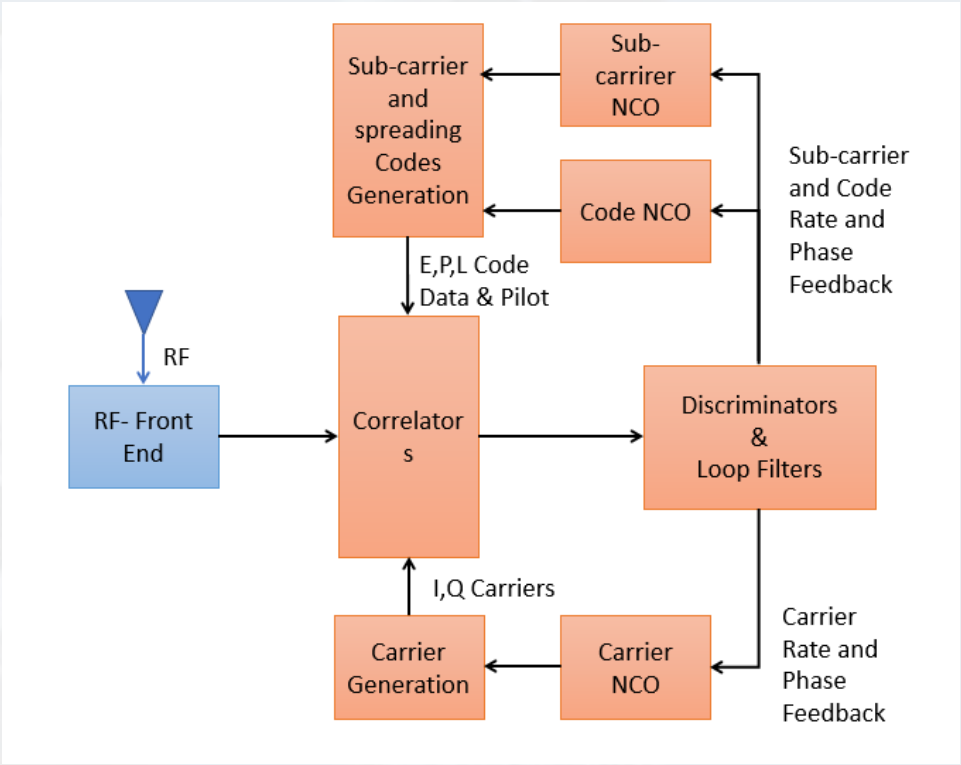
Architecture



Architecture of Payload Coherency Test Receiver

Universal Correlator

Constellation	Signal Supported	Modulation
NavIC	L5	BPSK(1), BOC(5,2)
	S	BPSK(1), BOC(5,2)
	L1C	SBOC
GPS	L1 C/A	BPSK(1)
	L1C	TMBOC
	L5	QPSK(10)
GLONASS	L1OC	BPSK(1), BOC(1,1)
Galileo	E1OS	CBOC(6,1,1/11)
	E5a,E5b	QPSK(10)



Measurement Accuracies

- Receiver Self Error Due To Thermal Noise

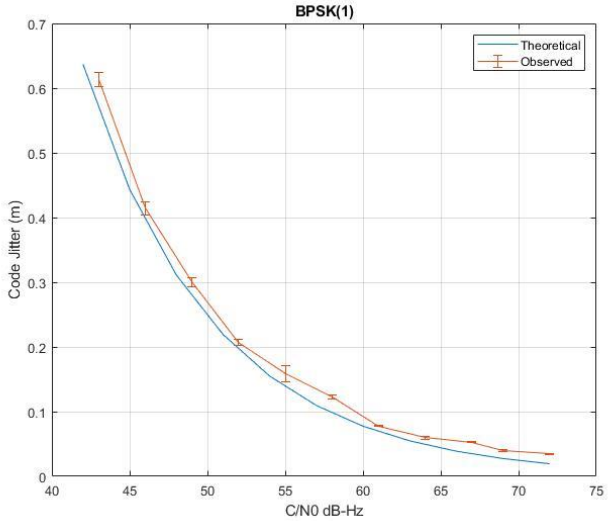
$$\sigma^2_{nelp} = \frac{B_L(1-0.25B_LT)\int_{-\beta/2}^{\beta/2} G_s(f)\sin^2(\pi f\Delta)df}{C/N_0\left(2\pi\int_{-\beta/2}^{\beta/2} fG_s(f)\sin(\pi f\Delta)df\right)^2}\left[1+\frac{\int_{-\beta/2}^{\beta/2} G_s(f)\cos^2(\pi f\Delta)df}{TC/N_0\left(\int_{-\beta/2}^{\beta/2} G_s(f)\cos(\pi f\Delta)df\right)^2}\right]$$

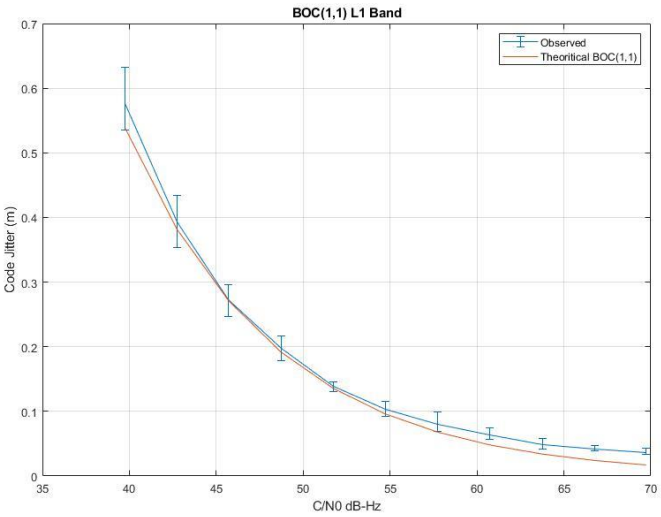
Parameter	DLL	SLL	PLL
Loop Filter Bandwidth	1	1	10
Chip Spacing	0.18/0.14	0.18/0.14	-

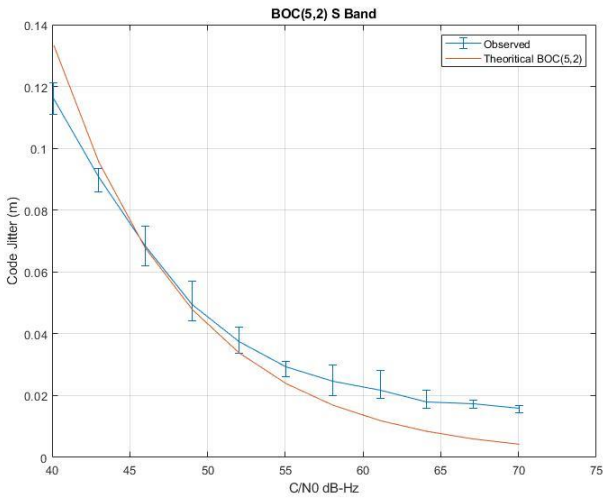
- Quantization in Frequency Tracking

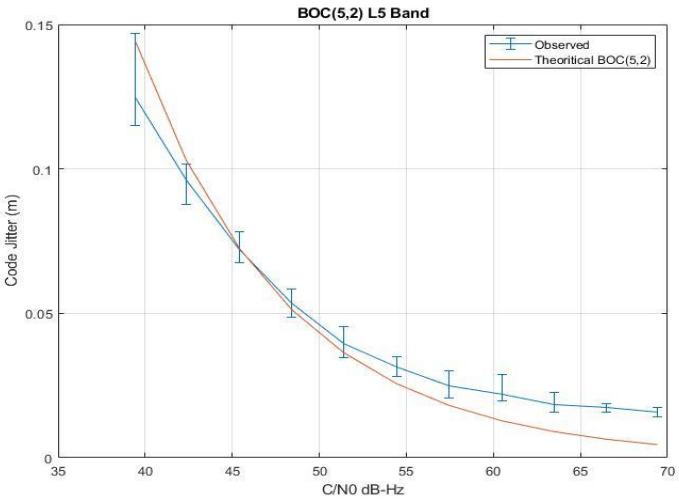
$$Quantization\ Step = \frac{Sampling\ Frequency\ \times Loop\ Update\ Period}{2^{NCO\ Width} \times Measurement\ Inst.\ Period}$$

Tracking Jitter Performance









Coherency Measurements

Code-Code Coherency

- Fluctuations in the difference between code phase measurements of two signals over time is known as code-code coherency.

Methodology:

- Subtraction of two code-phase observables

$$\varepsilon_k^{i,j} = C_k^i - C_k^j$$

- Moving Average of N-samples

$$\bar{\varepsilon} = \frac{1}{N}\sum_{k=1}^{N} \varepsilon_k^{i,j}$$

- Variance of Moving Average

$$\sigma_{\bar{\varepsilon}}^2 = \frac{\sigma_\varepsilon^2}{N} = \frac{2\sigma_C^2}{N}$$

- Choose N to meet the accuracy requirements.
- Similar Method can be extended for Carrier-Carrier Measurements.

Coherency Measurements

Code-Carrier Coherency

- Fluctuations in the difference between code phase and carrier phase measurements of single signals over time is known as code-carrier coherency.

Methodology:

- Subtraction of two code and carrier phase observables

$$\varepsilon_k^{i,j} = C_k^i - Car_k^j$$

- Moving Average of N-samples

$$\bar{\varepsilon} = \frac{1}{N}\sum_{k=1}^{N} \varepsilon_k^{i,j}$$

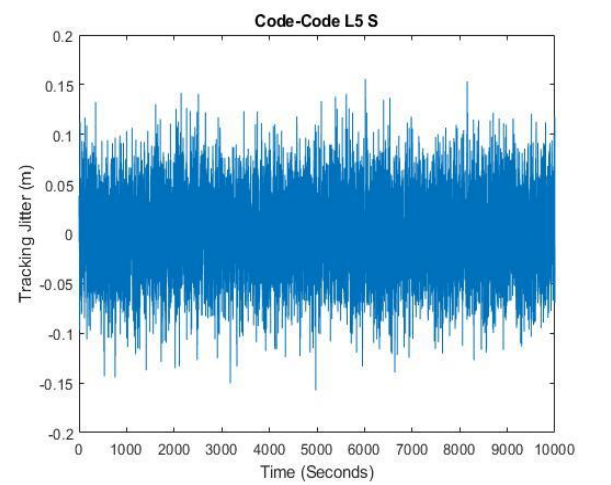
- Variance of Moving Average

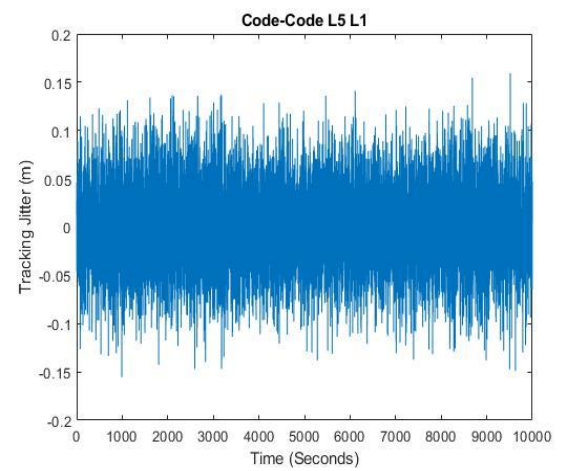
$$\sigma_{\bar{\varepsilon}}^2 = \frac{\sigma_\varepsilon^2}{N} = \frac{\sigma_C^2 + \sigma_{Car}^2}{N} \cong \frac{\sigma_C^2}{N}$$

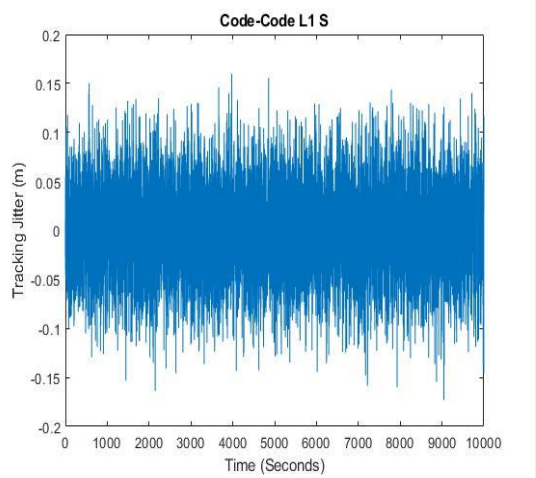
As $\sigma_C^2 \ll \sigma_{Car}^2$

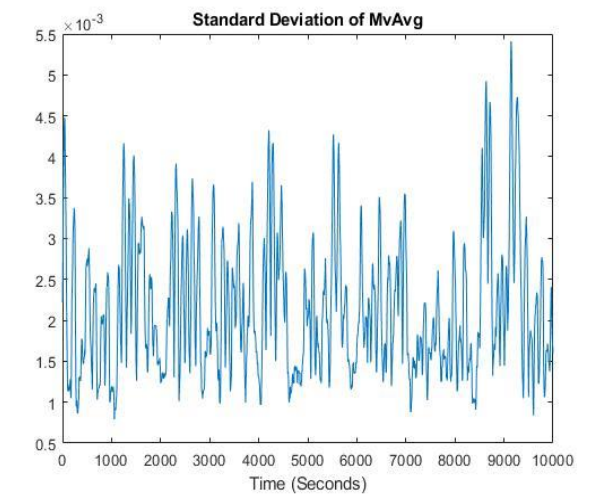
- Choose N to meet the accuracy requirements.

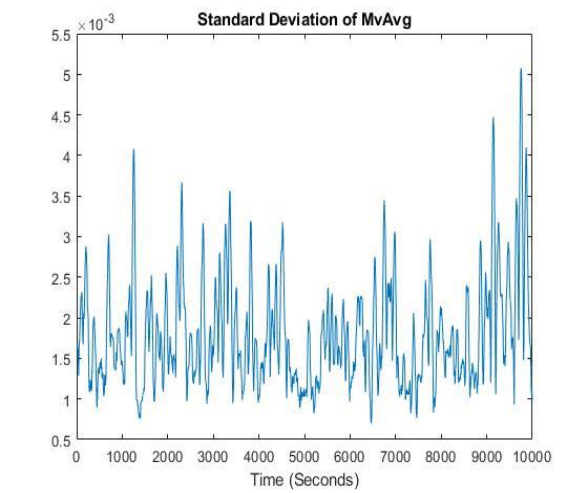
Results

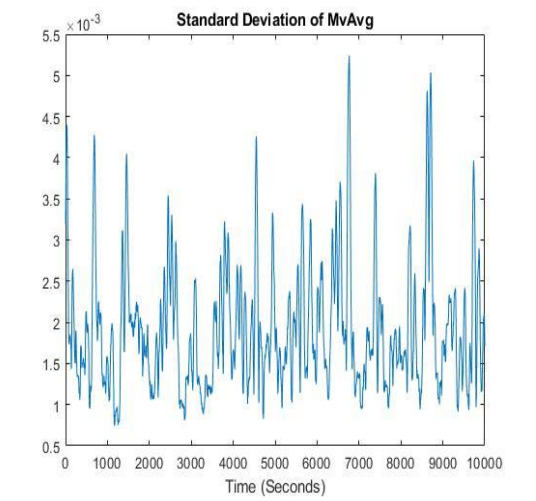






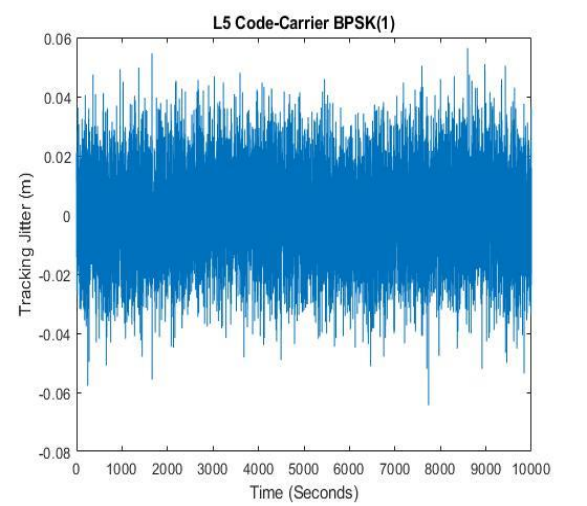


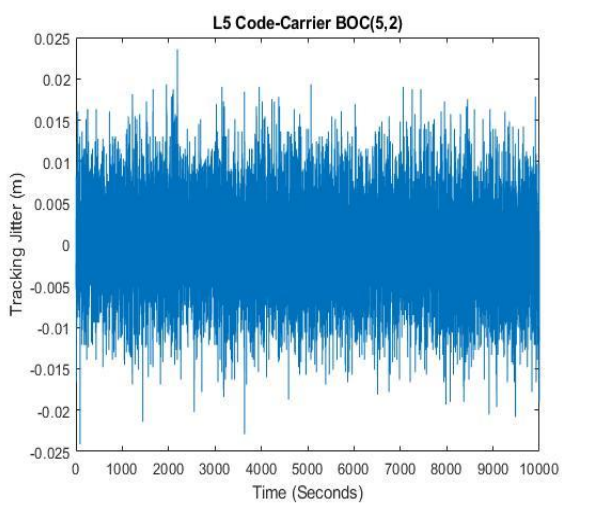


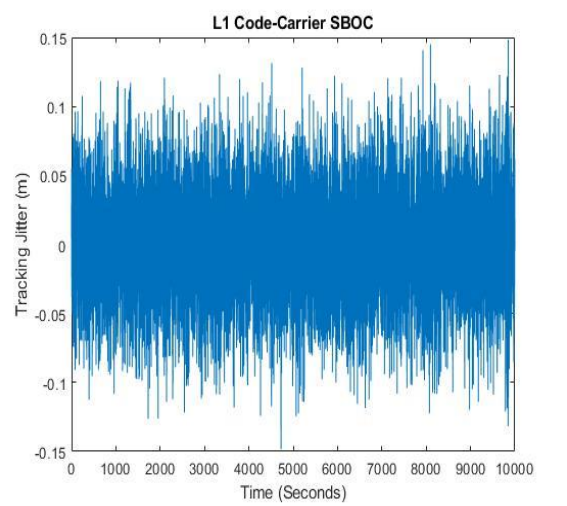


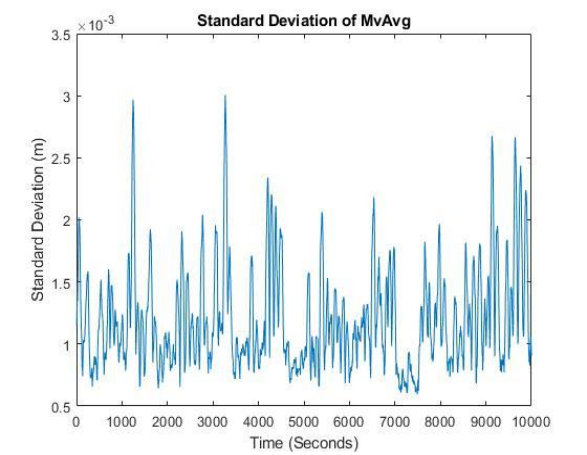
Code-Code Coherency Raw and Standard Deviation

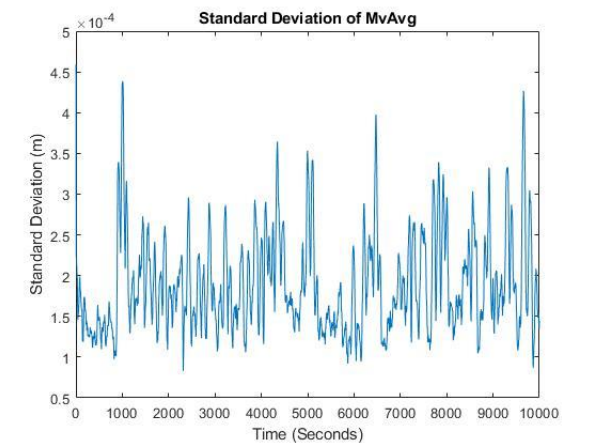
Results

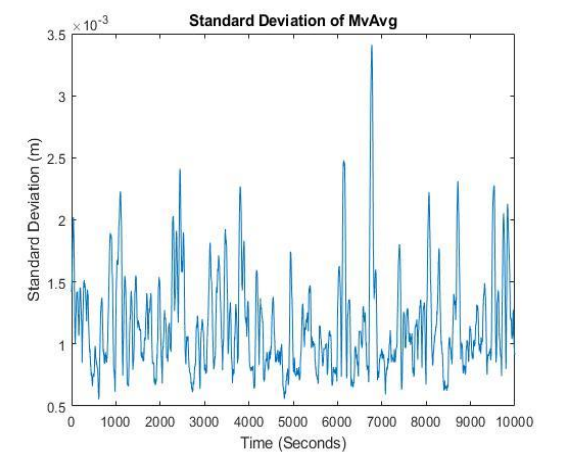






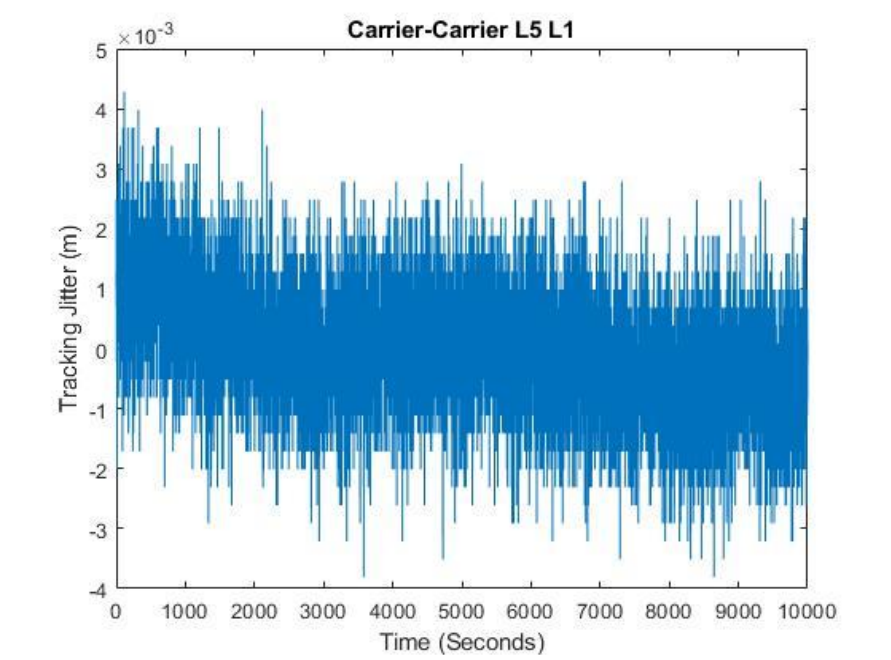


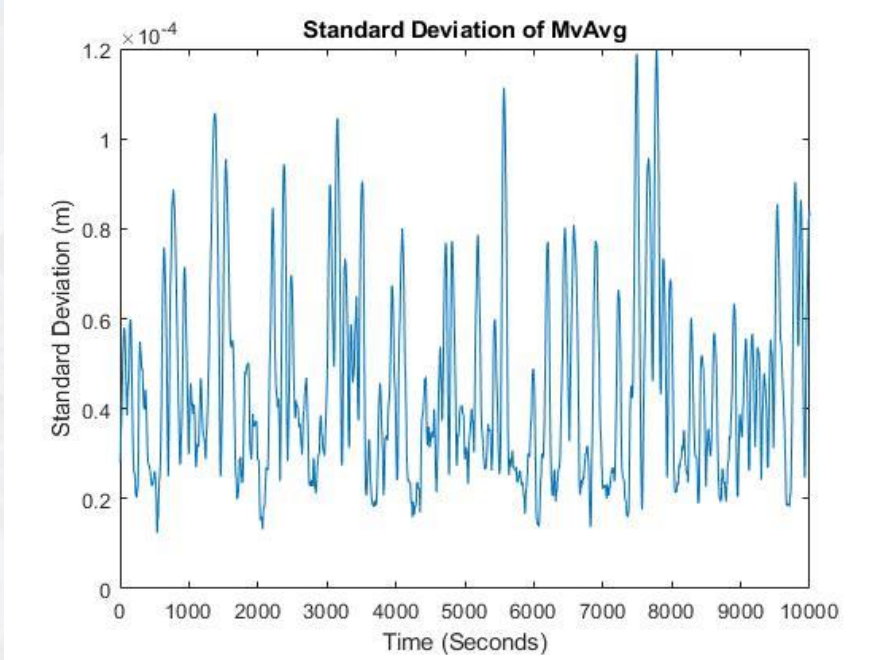




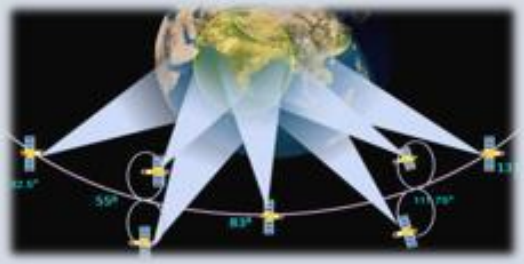
Code-Carrier Coherency Raw and Standard Deviation

Results





Carrier-Carrier Raw and Standard Deviation








Thank You