# NISAR S-SAR Internal Calibration for Payload Health Monitoring


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**Introduction:**

Calibration is the quantitative characterization of the performance of instrument. Synthetic Aperture Radar (SAR) calibration is essential to establish the true relationship between radar backscatter and geophysical. This process accounts for system biases, imbalances, and processing gains, ensuring measurement accuracy. Two main calibration approaches are: external calibration, which relies on artificial or extended targets, and internal calibration, which continuously monitors the health of payload subsystems and maintains SAR instrument stability throughout in-orbit operations.

**Objective of Calibration:**

The primary goal of SAR calibration is to monitor and correct variations in gain and phase that may arise due to hardware characteristics and environmental factors. This ensures that the SAR system maintains stable and accurate performance during operations.

**Calibration Methods in S-Band SAR (NISAR):**

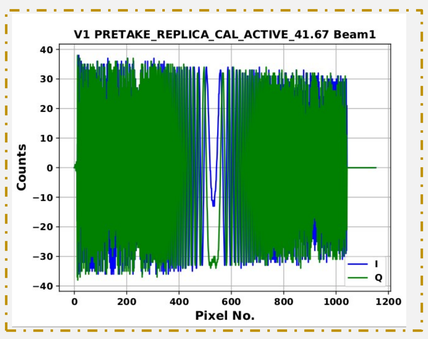
To address potential in-orbit gain and phase deviations across the 48 TRiMs(H & V Pol corresponding to H1,H2,V1 & V2 Boards), the S-Band SAR (NISAR) implements multiple internal calibration methods and checks the TRiM health status and its gain & phase deviation. Mainly two types of Internal Cal schemes proposed in NISAR S-SAR Band:

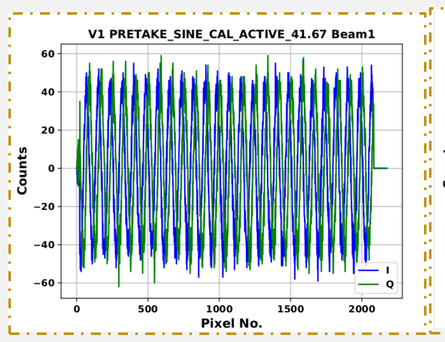
**1.Pre & Post Calibration:** Before & After Imaging operation

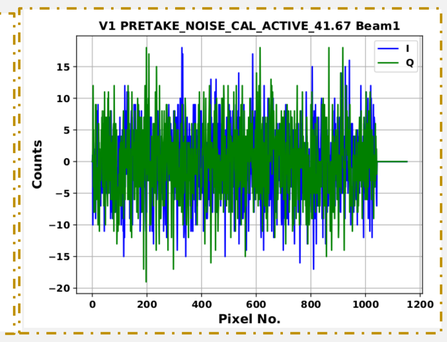
**2.On-Board Calibration:** Periodically after a cycle

## Pre & Post Calibration

| | |
|---|---|
| **SSPA Cal** | Transmit path characterization<br>Pulses:240 ,20 /TRiM |
| **LNA Cal** | Receive path characterization<br>Pulses:64 |
| **REPLICA Cal** | Antenna bypassed, Transmitted Signal power measurement , for Echo data compression/focussing<br>Pulses:80 ,20 /Chirp Bandwidth Frequency(10 MHz, 25MHz, 37.5MHz, 75MHz) |
| **NOISE Cal** | Antenna bypassed,System Noise measurement<br>Pulses:64 |
| **SINE Cal** | Phase bias estimation between Boards, facilitating digital beamforming (DBF)<br>Pulses:96 |



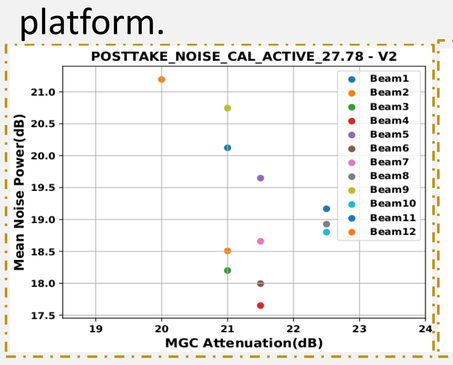



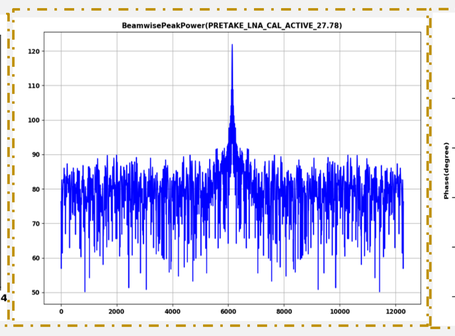

## On-board Calibration

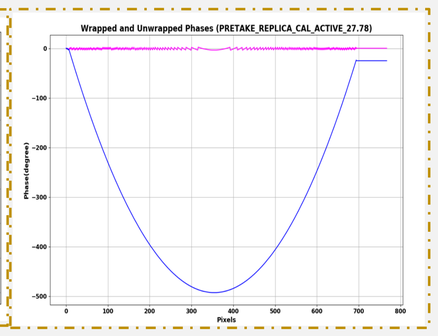
| | |
|---|---|
| **Short SSPA Cal** | Receive path characterization for a short duration |
| **Short REPLICA Cal** | Antenna bypassed, Transmitted Signal Power and Bandwidth Measurement for a short duration |
| **Short LNA Cal** | Receive path characterization for a short duration |
| **MGC Cal** | Average Noise Power estimation w.r.t MGC gains |

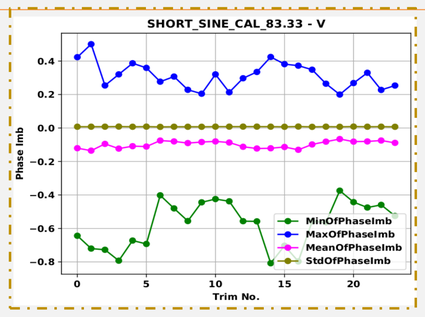
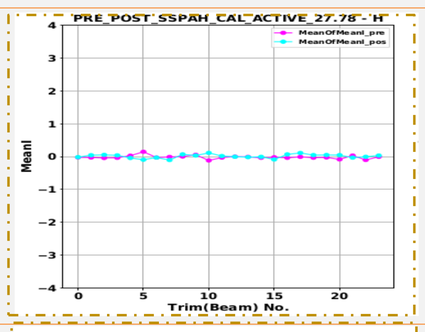
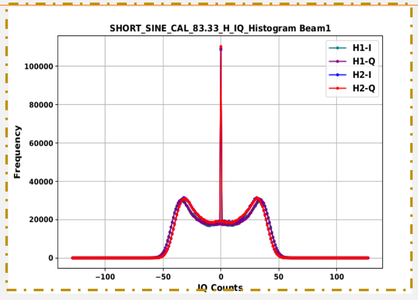
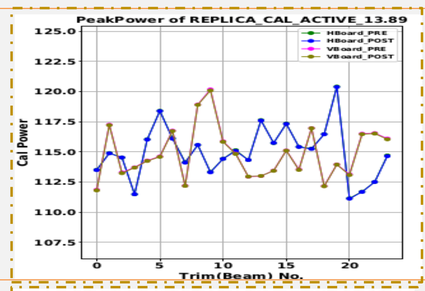
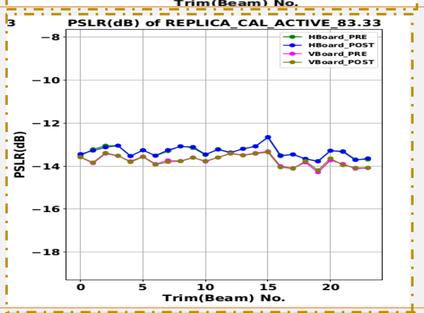
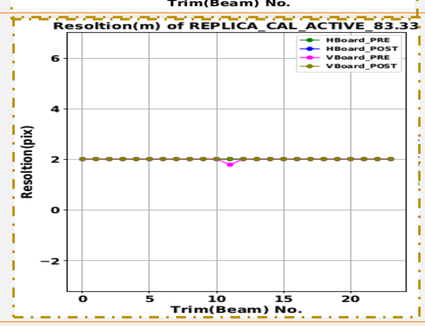
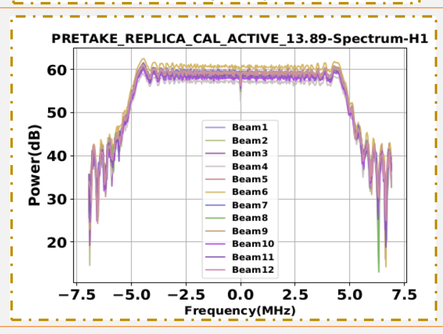
**Data Quality Parameters Assessment:**

Quality parameters are evaluated to ensure performance of TRiM modules consistency and accuracy, including imbalances, dynamic range, ISLR, and PSLR etc. The automated L0-DQE software assesses these parameters, and following the launch, the system is monitored continuously via the IMGEOS platform.




| Quality Parameters | Applicable for Cal | Results of Lab Characterization Data |
|---|---|---|
| Power & Phase Imbalance | Pre & Post SSPA Cal, LNA Cal, Replica Cal, Sine Cal, Short SSPA, Short LNA, Short Replica Cal |  |
| I/Q Mean & Standard deviation | Pre & Post and On-board Cal operations |  |
| Data histograms (I/Q) , Data Dynamic range (saturation count percentage and Peak of the signal) | Pre & Post and On-board Cal operations |  |
| Range-compressed Cal Power & Phase at Peak Power | Pre & Post Replica Cal, LNA Cal, SSPA Cal |  |
| ISLR & PSLR | Pre & Post Replica Cal, LNA Cal, SSPA Cal |  |
| 3dB Resolution | Pre & Post Replica Cal, LNA Cal, SSPA Cal |  |
| Spectrum and Bandwidth | Pre & Post Replica and Short Replica Cal |  |

**Results & Observations:**

- ✓ Analysis of calibration data shows that Statistical Parameters, Power and Phase imbalances across the TRiMs are within the expected ranges.
- ✓ Additionally, data consistency observed across various test phases confirms stable system behavior and reliable calibration operation.
- ✓ The impulse response parameters(Cal Power, ISLR & PSLR) estimated from replica Cal are following the designed specifications.
- ✓ Noise Cal data showing stable behaviour for all test phases ensuring consistency for various MGC gains.
- ✓ Data Dynamic Range for all Cal is within the expected range.

**Conclusion:**

S-SAR internal calibration data is evaluated on a regular basis and compared with ground reference test data till the lifespan of sensor for health monitoring. Any deviations from the expected values are analyzed and provided as feedback to Payload team to restore the performance of the system.