# LOW-COST GROUND-BASED BEACON SATELLITE RECEIVER FOR TEC MEASUREMENT

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## Objetives

- In this work will be explore the design and implementation of a low-cost ground-based beacon satellite receiver network to study the SpreadF phenomena at low-latitude ionospheric plasma on the ecuatorial region of Peru. [1]

## System specifications

**The more extensive the reception network, the more accurate the reconstruction.**

- The Computerized Ionospheric Tomography (CIT) technical will enable us to obtain density profiles with TEC information provided by the receivers.

**TEC calculations are based on phase difference technique**

- Two modulated waves transmitted from LEO satellites are received and process in different ground stations. [2]

**Different frequencies simultaneously**

- Each receiver must be able to detect the passage of multiple satellites at different frequencies simultaneously.

## Proposal

Table I. SDR's Hardware Comparison

| | LIME SDR | USRP B210 | BLADE RF | Hack RF One | RTL SDR |
|---|---|---|---|---|---|
| Price ($) | 299 | 1200 | 300-450 | 240 - 350 | 20 |
| Frequency (MHz) | 0.1 3800 | 70 6000 | 300 3800 | 1 6000 | 0.5 1750 |
| TX/RX | 6 RX 4 TX | 2 RX 2 TX | RX TX | RX TX | RX |
| Resolution (Bits) | 12 | 14 | 12 | 8 | 8 |
| Interface USB | 3.0 | 3.0 | 3.0 | 2.0 | 2.0 |
| Sample Rate (Msps) | 20 | 61.44 | 40 | 20 | 2.4 |
| Bandwidth (MHz) | 64 | 56 | 28 | 20 | 3.2 |

- The proposal pretend explore other less expensive receiver options based on software defined radio technology , like the "BladeRF" from NUAND and "HackRF One" by Great Scott Gadget.
- The Universal Software Radio Peripheral (USRP) is one of the most well know SDR's devices

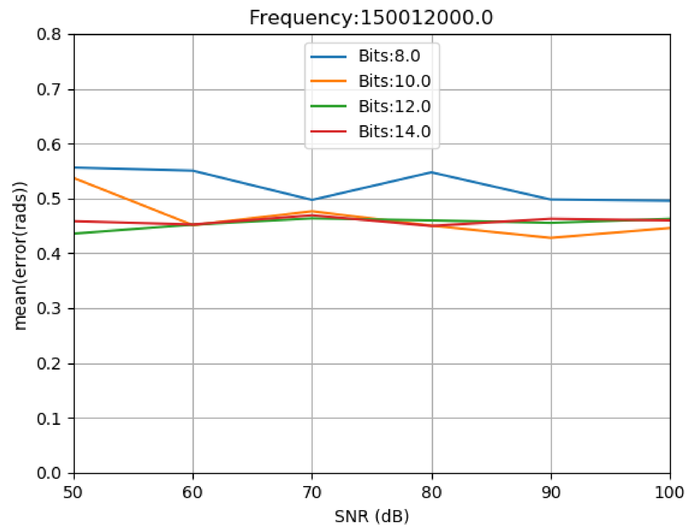


Figure 1. BladeRF case mean error phase for different SNRs

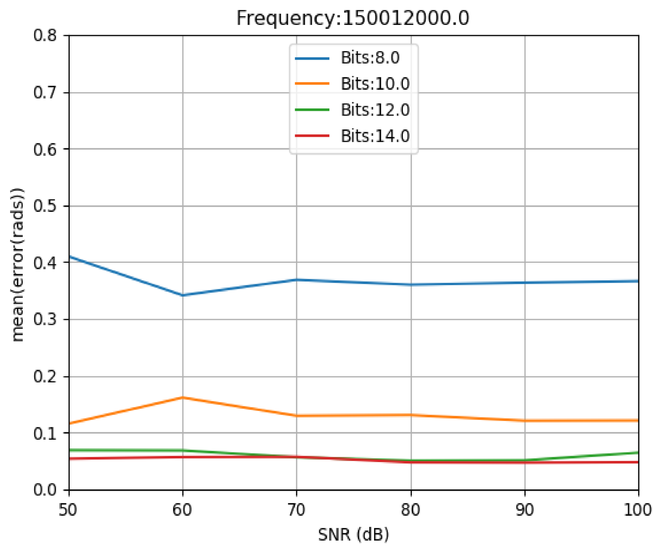


Figure 2. USRP case mean error phase for different SNRs

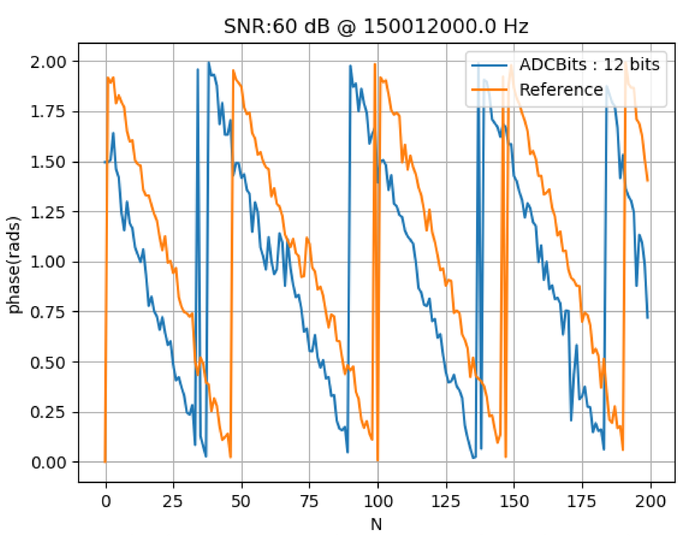


Figure 3. BladeRF case phase results plotted with reference signal.

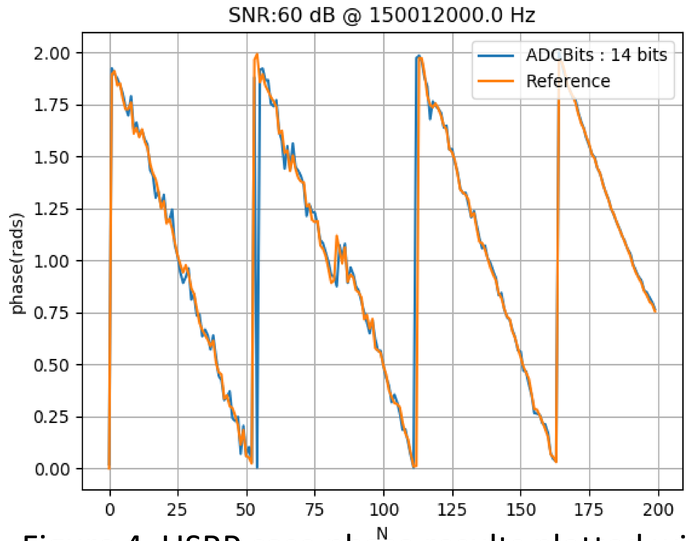


Figure 4. USRP case phase results plotted with reference signal.

## Methodology

- A code was elaborated to simulate of phase errors introduce by the receiver main processing stages.
- **Architecture type** (superheterodyne and heterodyne), **Analog Digital Conversion** (ADC) and the **Digital down conversion** (DDC) characteristics were taken in consideration for **different Signal to Noise Ratio** (SNR) scenarios.

## Results

- BladeRF use the concept of direct conversion, there is no need of up/down converting from/to an intermediate frequency. The phase results are shown in Figure 3 for 60 dB as well as the mean phase error for different SNRs in Figure 1.
- USRP same phase plots are shown in Figure 2 and 4 in order to compare the results.
- **BladeRF shown around 0.4 rads more mean error phase than the USRP.**

## Conclusions

Results are encourage since ADC was not as representative expected. Figure 1 and 2 shows no significant difference in term of phase between the use of 10,12 or 14 bits in the ADC.

Superheterodyne architecture shown effects of the Local Oscillator (LO) not synchronized in phase with incoming carrier frequency signal. Experimental data of phase stability studies focus in synchronization is present independently in [3].

**BladeRF shown good cost efficient characteristics but experimental data need to be recollected.**

[1] Merino, Meyer, et al, Tomographic Reconstruction of the Ionospheric Plasma over LISN, LAWPP 2017.
[2] Kudeki, Erhan., Applications of Radiowave Propagation. ECE 458, University of Illinois at Urbana-Champaign.
[3] Inonan, Marcos, Low Cost passive coherent radar for TEC measurements, CEDAR 2018.