EFFECTS OF OSCILLATORS PERFORMANCE ON THE SPREAD SPECTRUM COMMUNICATION

Author (1) Pietro Giorgio
Thales Alenia Space Italia, via Saccomuro 24, 00131 Rome, +39 06 4151 4436
pietro.giorgio@thalesaleniaspace.com
Author (2) Alessandro Pisano
Thales Alenia Space Italia, via Saccomuro 24, 00131 Rome, +39 06 4151 2227
alessandro.pisano@thalesaleniaspace.com
Author (3) Rodolfo Mura
Thales Alenia Space Italia, via Saccomuro 24, 00131 Rome, +39 06 4151 4309
rodolfo.mura@thalesaleniaspace.com
Author (4) Vincenzo Marziale
Thales Alenia Space Italia, via Saccomuro 24, 00131 Rome, +39 06 4151 2261
vincenzo.marziale@thalesaleniaspace.com

Abstract

In the Spread Spectrum (SS) modulation/demodulation, a SS receiver first replicates the Pseudo Random Noise (PRN) code that shall be acquired; then it shifts the phase of a replica code until it correlates with the transmitted PRN code. This process is called Code synchronization.

Code synchronous is usually achieved in two steps:

- **code acquisition** searching an estimate for the locally generated code phase that is to be aligned with the received code sequence to within one chip duration.
- **code** and **carrier tracking** process tracking any changes in the received code phase, when the estimated code phase is already verified and the synchronizer transmission is declared in lock.

The prime task of the SS receiver is to generate a local replica of the received spreading code to re-modulate or de-spread the incoming signal. When the local code phase is time synchronized to the received code to within a fraction of chip code phase offset, the received spread-spectrum signal collapses in bandwidth and reverts to its original narrowband form and the conventional detection techniques can be applied to recover the data.

The main purpose of tracking is to refine the coarse values of code phase and frequency and to keep track of these as the signal properties change over time.

The speed with which a transmitter's signal can be acquired is strongly dependent on the **frequency** difference between transmitter and receiver. It is also dependent on the *time* difference between the transmitter's clock and the receiver's clock. The larger these differences, the longer it takes to acquire.

The frequency difference between transmitter and receiver and the time difference are dependent on the frequency sources that SS modulators and demodulators use.

In the paper we will analyse the effects of these frequency sources (oscillators) on the Spread Spectrum communication.

The main oscillator parameters impacting the Code and Carrier acquisition are the following:

- Accuracy
- Allan deviation
- Oscillator’s vibration sensitivity

The oscillator **Accuracy** has an impact on the Time Acquisition Code, on the Signal to Noise Ratio, on the Probability of False Alarm and on the Noise Variance in PN Code Acquisition while it has an impact on the Code loop thermal noise error and Maximum LOS dynamic stress threshold in PN Code Tracking. The **Oscillator's g-sensitivity** and the **Allan deviation** have an impact on the PLL Tracking Loop Errors in Carrier Tracking.

Considering a Spread Spectrum transmission to a GEO satellite, in K band, we have analyzed the effect of different kind of oscillators (Temperature-Controlled Crystal Oscillator or TCXO, Microcomputer Compensated Crystal Oscillator or MCXO, Oven-Controlled Crystal Oscillator or OCXO, Rubidium or Rb, Rubidium-Crystal Oscillator or RbXO and Cesium or Cs) [1] on the PN Code Acquisition & Tracking and on the Carrier Tracking performance.

The Code Acquisition and the Code Tracking are actually impacted by the oscillators Accuracy, but the impact is negligible in the considered scenario, regardless of the oscillators, unlike the Carrier Tracking.

The Carrier Tracking is the weak point in the SS communication. The Carrier Tracking loop depends heavily on the performance of the oscillators. For instance, in case of Oscillator's vibration sensitivity equal to 1E-9, no oscillator is compatible with the considered scenario, while in a case of Oscillator's vibration sensitivity equal to 2E-10, only a few are compatible (bold numbers in the Table I).

	Crystal oscillators			***Atomic oscillators***		
	TCXO	**MCXO**	**OCXO**	**Rb**	**RbXO**	**Cs**
Allan deviation	1E-9	3E-10	1E-12	3E-12	5E-12	5E-11
PLL Tracking Loop Error (second-order loop)	240°	74°	**15°**	**15°**	**15°**	19°
PLL Tracking Loop Error (third-order loop)	267°	81°	**11°**	**11°**	**11°**	17°

TABLE I. CARRIER TRACKING PERFORMANCE VS OSCILLATORS [OSCILLATOR VIBRATION SENSITIVITY 2E-10]

References

[1] John R. Vig, "Introduction to Quartz Frequency Standards", Army Research Laboratory Electronics and Power Sources Directorate Fort Monmouth, NJ 07703-5601, U.S.A.,1992 (Page40)